SCIENCE

CONTENTS

THE AERIAL TRANSMISSION PROBLEMS[1]

THE title of my address suggests that I propose to discuss the problems connected with wireless telegraphy and telephony. It should be observed, however, that ordinary telegraphy and telephony and electrical transmission of large amounts of power is aerial transmission and faces some of the problems which confront us to-day in wireless transmission. But, of course, the problems of aerial transmission in their relation to wireless telegraphy and telephony present their most interesting aspect and I shall, therefore, devote most of my time this evening to this particular aspect, of the problem of aerial transmission.

Permit me now to differentiate, briefly, wireless transmission from ordinary electrical transmission.
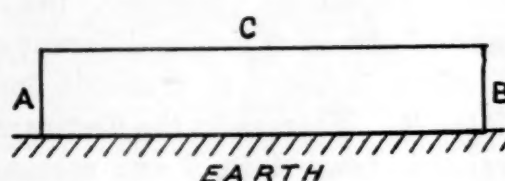
FIG. 1.

Fig. 1 represents the simplest form of ordinary electrical transmission. A wire, ACB, is connected to the earth at each end. A generator station at A sends electrical energy to receiving apparatus stationed at B. The motion of electricity started at A is transmitted along the wire C to the station B and then is completed through the conducting ground between B and A.

[1] An address delivered before the National Academy of Science, at its meeting in New York, November 15, 1915.

Fig. 2 represents the simplest form of wireless transmission. An electrical gen-

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Fig. 2.

erator at A sends through a vertical wire electrical energy to a vertical wire at station B. There is motion of electricity between A and B, but only through the earth. The second case is similar to the first except that in the second case there is no wire C, connecting station A to station B; hence, on account of the absence of the connecting wire C, we call the second method of transmission a ''wireless'' method. This second method is particularly important when it is impossible to employ a connecting wire between the two stations, as, for instance, between two ships at sea, or between a ship and the shore.

This more or less insignificant difference in the structures, by means of which we transmit, necessitates, however, the employment of almost radically different electrical actions in order to transmit energy from A to B. Whereas in the first case we can transmit from A to B any reasonable amount of energy by a constant or a slowly varying motion of electricity, we have to adopt in the second case a very rapidly oscil-

EARTH

Fig. 3.

lating motion of electricity. The simplest and historically the oldest method of producing a rapidly oscillating motion of electricity was obtained as follows: The vertical wire at the transmitting station A, called

the antenna, has an air gap cd and the two parts of the antenna, the upper part which is insulated, and the lower part which is connected to the earth, are connected by means of wires a and b to a very high electrical tension such as is employed in our automobiles for ignition or in the production of X-rays by means of the X-ray tubes and the induction coil. This high electrical tension forces one kind of electricity into the upper part of the antenna and the opposite kind into the lower part of the antenna which is connected to the earth. The two parts of the antenna form the two conducting coatings of a Leyden jar; the surrounding atmosphere, of which the air gap cd is a part, separates the two coatings. When the electrical tension is very high it breaks through the air space cd, that is, a spark jumps between the two metal balls cd and forms there a conducting path, that is an easy path for the motion of the electricities which are separated, one crowded into the upper part of the antenna, and the other into the lower part and the earth. These two separated electricities which attract each other will rush toward each other as soon as the passage through the air gap cd has been established, and they will move as fast as the laws of motion of electricities command them to do. Now these laws demand that this motion be an oscillatory one. This oscillatory motion of electricity during a discharge of a Leyden jar was discovered by our great Joseph Henry in 1840 when he was professor of physics at Princeton College, and the laws of motion were first formulated in 1855 by the famous William Thomson, who died a few years ago as Lord Kelvin. The oscillatory motion of electricity and the laws governing it can be best illustrated by the following simple mechanical analogy. A stiff steel tongue ab which is fastened at its lower end a to a table is displaced by the tension of a string d from

its position of equilibrium. Increase the tension until the string *d* breaks when the displaced steel tongue is released; it will then return to its normal position after per-
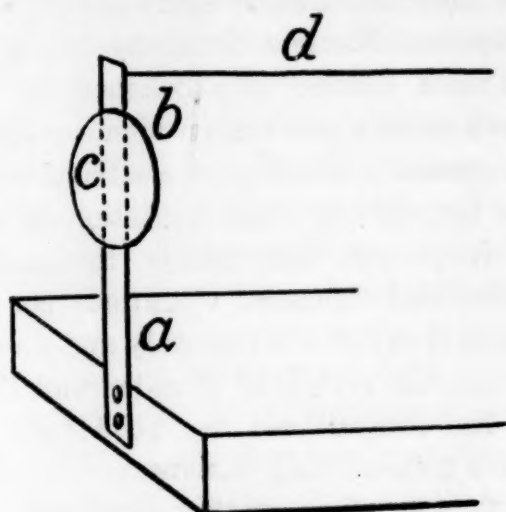

FIG. 4.

forming a few oscillatory movements. The analogy between the motion of the steel tongue and the motion of electricity referred to above is quite complete and to make it even more complete I attach a cardboard disc *C* which by transferring a considerable part of the motion of the tongue to the surrounding air will accelerate the dying out of the oscillatory motion of the tongue by the transference of the energy of the vibrating cardboard to the surrounding air. Here is a tuning fork which I pluck with my fingers instead of employing the tension of the string, or which is still better, I give it a gentle impulse with a soft hammer. After each impulse the fork oscillates, imparting some of its motion to the surrounding air, and the vibratory motion of the air propagated in all directions impinges upon your auditory organs and thereby produces in your consciousness the sensation of sound. In the same manner the vibratory motion of electricity in the antenna is communicated to the electricity near the surface of the earth, causing it to move in the same vibratory fashion; these vibrations spread out in all directions and

travel along the surface with the velocity of light, that is, about 180,000 miles a second. This propagation along the surface of the earth of the oscillatory motion of electricity is called electrical wave motion, just as the propagation of the vibratory motion of the tuning fork through the air is called wave motion. Just as the sound waves produced by the vibration of the tuning fork or by my vocal cords spread out in every direction, getting feebler as they progress further and further, but producing a sensation of sound in every healthy ear which they find anywhere, so the propagation of the vibratory motion of electricity along the surface of the earth spreads out in every direction, getting feebler as it advances further from the sending antenna, but producing a definite effect in every upright wire like *B* in Fig. 3, which effect can be detected very clearly by a suitable electrical instrument connected with the wire *B*. This, briefly stated, is wireless transmission of electrical signals.

We often hear that wireless transmission is only a practical application of electrical waves discovered by a German, the late Professor Hertz; that it is an art which formed its first roots in German soil, whereas in reality it is a particular case of the oscillatory motion of electricity discovered by Joseph Henry and the laws of which were formulated by Kelvin. It is true that Hertz employed these oscillations more skilfully than anybody else ever did prior to his time, and thereby succeeded improving experimentally the complete validity of the physical foundation of the great electromagnetic theory which was conceived and formulated by Clerk Maxwell, the great Scotch physicist. It is also true that Guglielmo Marconi in 1895, when a mere youth of twenty-one, fascinated by the beauty of the Hertzian experiments, was busy with Hertzian electrical oscillators

when he suddenly discovered that an oscillator connected to the earth, as described in Fig. 3, was much more efficient than any other form of oscillator in propagating an oscillatory motion of electricity from any given point of the earth to any other point. That discovery gave birth to wireless telegraphy. But, nevertheless, this discovery could have been made prior to the time of Hertz by any one who understood the work of Henry and of Kelvin and interested himself in the study of electrical oscillators of various types. I think that Marconi discovered wireless telegraphy; he did not invent it. The inventing period in this new art started after the discovery was made and when various problems connected with the development of this new art presented themselves.

The earliest attempts to advance the new art were in the direction of increasing the distance which could be bridged over by this new method of electrical transmission. As early as 1902 Marconi attempted the bold experiment of sending wireless signals across the Atlantic. These attempts resulted at first in an enormous increase in the height of the antennæ and the power of the generators which create the electrical oscillations at the sending station. The wireless structures employed as sending antennæ were anything but wireless, and the generating stations which fed them were veritable thunder and lightning factories. The roar of the thundering sparks transmitting signals between England and Newfoundland would terrify the whole neighborhood of the transmitting station, and yet at the receiving station there would be only very faint clicks in a very sensitive telephone held over the anxious ear of a skilled operator. Physicists with artistic temperament, that is, with a sense of right proportions, always felt that these thunder and lightning factories had no place in wireless trans-

mission. Three years ago I suggested that if a little more science were put into the General Electric Company we would soon have a noiseless generator which would replace those thundering spark-gaps. Well, the General Electric Company has put a little more science into Schenectady and we have today a generator which can supply any reasonable amount of electrical power in the form of electrical oscillations of very high frequency, say, twenty thousand to two hundred thousand vibrations per second, and it supplies it smoothly and silently. The horrible racket of thunder and lightning has disappeared for good from the wireless transmitting stations.

In the meantime another great and wonderful advance has reached the wireless transmitting station. This advance is so far reaching in its purely scientific aspect that I feel constrained to devote to it a few brief moments. Consider a generator of electrical oscillations sending out from a wireless station at A (Fig. 5) a continuous train of electrical waves *ab* of high frequency or pitch, say fifty thousand periods per second. A person with a telephone receiver at the receiving station B would hear nothing, because the pitch of the re-
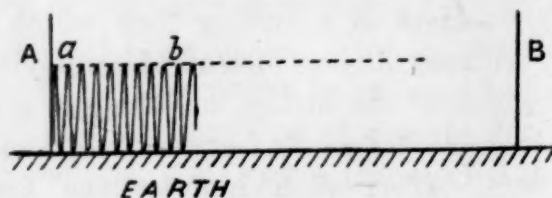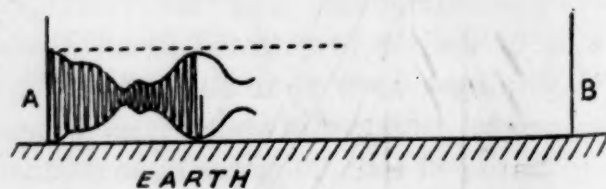

FIG. 5.

FIG. 6.

ceived waves is too high. Suppose now that by some means the generator is made to vary the amplitude of the outgoing

waves as indicated by the thick wavy curve in Fig. 6, and suppose that these variations follow the law of variation of sound waves in articulate speech, then the man holding a telephone to his ear at the receiving station B, equipped with a suitable apparatus, will hear articulate speech. This idea is not new; I disclosed it in 1902 to Professor Henry Perkins, of Trinity College, Hartford, and I consider the idea as obvious. But what I do not consider as obvious is the manner in which a huge generator of electrical power can be made to vary the power which it delivers in that most complicated way which we human beings practise when we vibrate our vocal cords in order to produce articulate speech. When the Western Electric Company and the American Telephone and Telegraph Company transmitted articulate speech between Arlington and Honolulu they actually controlled by the human voice the operation of a huge electrical generator generating many horse power, and it is plain that the same method can be easily extended so as to control any amount of power by the human voice. It is, indeed, a great achievement. It may be claimed that the achievement is nothing startlingly new, for do we not know that with a tiny spark we may start a huge explosion and do we not see every day that the chauffeur by minute twists of his hand or foot can regulate the power of the gas engine in our automobiles? Yes, I admit that there is a resemblance, but the resemblance is a very coarse one. When you find a chauffeur who can regulate the movement of his car in such a way that it will vibrate in accordance with the vibrations of articulate speech, then that chauffeur will have accomplished the same thing which the operator at the Arlington Station did when by the controlling action of his voice he made his huge generator speak the words which were heard at Honolulu, five thousand miles away. And yet the achievement is perhaps not quite as new as it might appear. When a Paderewsky with Beethoven's Sonata in his head makes Beethoven's ideas control the strenuous movements of his body which agitate the strings of the piano, then I see something which the operator at Arlington might have been unconsciously copying. I throw this out as a suggestion to the biologists, the physiologists, and the neurologists, who are not always aware of what is going on in other departments of physical science, just as we physicists are often totally ignorant of the great researches in biology, physiology and neurology.

Let us now turn our attention to the electrical waves which carried that articulate message from Arlington to Honolulu and examine their condition when they arrived at Honolulu. These waves were so feeble that no electrical instrument ever invented by man could, unaided, ever detect their presence. This brings me to a point which I discussed before this academy just four years ago. I told you then that I had discovered an electrical machine which stimulated by a feeble electrical wave of high frequency would reproduce that wave magnified to any extent. I believe that in that discussion was the first mention of the electrical "amplifiers" which play a most important part to-day in wireless transmission. It is far from me to claim the whole credit for the work which has been done in this direction; on the contrary, most of the credit for developing the idea of electrical amplifiers of to-day and of giving them a thoroughly fool-proof form belongs to the research laboratory of the General Electric Company and of the American Telephone and Telegraph Company, and I cheerfully congratulate them upon the wonderful achievement.

Now what is an amplifier of these high frequency electrical waves? Broadly speak-

ing, it is a local source of electrical energy which stimulated by an electrical wave no matter how feeble will give a perfect reproduction of that wave magnified to any extent that may be desirable. When the electrical wave conveying speech from Arlington to Honolulu arrived at Honolulu it was perfectly exhausted and so feeble that its action could not produce any perceptible direct effect upon any instrument ever constructed by man. The electrical amplifier, that is, the local electrical generator, then threw in its wonderful work. Stimulated by the feeble wave it reproduced it in a tremendously magnified form without in any way modifying its character. The man at Honolulu, with the aid of the local amplifier, not only heard the voice of Arlington, five thousand miles away, but by the characteristics of the articulation he recognized the speaker: so perfect was the reproduction by the amplifier! In fact, we may say that the electrical amplifier at Honolulu stimulated by the waves coming from Arlington created over again at Honolulu the articulate speech uttered at Arlington. Permit me now to offer a suggestion which has occurred to me often, and which, I think, may be of some interest to the biologist and the neurologist. We all know that the eye, the ear, and other organs which are the instruments of our perceptions are extremely sensitive. For instance, the amount of energy conveyed to the eye by light, which is just visible, is almost incredibly small. The question arises now, does that energy produce in us directly the sensation of light or does it serve as a stimulus, only, for a local source of energy, the sensatory organs, which amplify it and reproduce it somewhat in the manner as the electrical amplifier reproduces, on a very much magnified scale, the faint traces of a wireless wave? The structure of the nervous system seems to support this bit of speculation and I trust

that you will not be too severe with me for indulging in it.

From this very rough sketch which I have just drawn for you describing the present state of wireless transmission it appears that there are at present no obstacles in the way of extending the distance of wireless communication to any point on the earth. And yet there are, and they are of the most formidable character. These obstacles are due to the interference produced by electrical waves which are passing through the terrestrial atmosphere continuously. One may say that electrical waves are just as numerous in the atmosphere as water waves are on the surface of the sea. They are of the same general character and probably due to the same causes as the electrical waves which interfere with our telephone and telegraph lines and with power transmission wires during a thunderstorm. They are, in fact, the electrical tremors of minute thunderstorms or of powerful but very distant thunderstorms. We were not aware of their presence until we attempted to magnify the minute electrical wave coming from a very distant signalling station. An engineer of the American Telephone and Telegraph Company who was on the Pacific Coast and watched for the famous telephone message from Arlington reports that at times it was drowned completely in a roar of musketry. This roar was due to the action of the electrical waves produced by the incessant electrical discharges in the atmosphere. The wireless telegraph engineer calls these discharges the "static" and he hates them, because they interfere with his business, but the physicist and particularly the meteorologist will hail their appearance with delight, because they offer him a new and most unexpected aid for the study of the activities in the terrestrial atmosphere.

All attempts up to the present time which

the so-called "practical" wireless engineer has made in the direction of overcoming the interference of the "static" consisted in increasing continually the power applied at the signalling station so as to make the signals at their arrival at the receiving station stronger than the signals made there by the static. These attempts failed, as they should. The static is an act of God and his acts can not be neutralized by brute force. The machinery of nature will not interfere with the machinery constructed by man if man puts a sufficient amount of intelligence into his machine. In other words, the practise of the wireless art needs more pure science before it can expect to overcome the very serious interferences due to the action of the static. Ordinary electrical tuning will not do, because every system which is highly selective through ordinary tuning is also highly sonorous. Every tap of the static will cause it to vibrate and it will vibrate in the same way as when it is under the action of the signalling waves. We must look for some other form of electrical selectivity, and this is the last point which I wish to bring before you now, but only very briefly.

The eye sees a very narrow strip of wave frequencies which are sent from a radiating body; the ear hears a very narrow strip of wave frequencies which vibrating bodies can send out. Physiological optics and physiological acoustics deal with these remarkable facts. Now the reason why the eye is blind and the ear is deaf to an enormous range of frequencies is certainly not due to anything like ordinary selectivity produced by tuning. The selectivity must be due to something else. Physicists see resonance and tuning wherever they find selectivity, but it is high time to formulate broader views.

Fifteen years ago I published several investigations which deal with electrical motion in sectional wave conductors. One of these resulted in the now well-known loaded telephone line. I regret that the technical importance of this invention, by attracting too much attention, has overshadowed completely the full meaning of the general mathematical theory which underlies it. This theory says that sectional wave conductors can be made which will absorb almost completely all waves above or below a certain small range of frequencies, and the selectivity thus obtained has nothing to do with ordinary electrical tuning. In other words, the selectivity of the eye and of the ear can be imitated by coarse structures like sectional wave conductors. Electrical pulses produced by the static are for the most part very short and their action is equivalent to the action of highly damped electrical oscillations of very high pitch. This action can be entirely absorbed so that no part of it reaches the receiving apparatus of a wireless receiving station if between the antenna and the receiving apparatus a sectional wave conductor is employed which will not transmit electrical waves of a frequency higher than a given range of frequencies. The station becomes then an ear which is quite sensitive for frequencies which are in the vicinity of the signalling frequency, but which is stone deaf to frequencies which are considerably beyond this range as most static disturbances are. Similarly, a sectional wave conductor can be constructed which is quite responsive to frequencies in the vicinity of the signalling frequency, but absorbs almost completely everything below this range. My theoretical and experimental investigations encourage me in the belief that a perfect barrier has been found against disturbances due to the so-called static, and that the distances of uninterrupted wireless telegraphy and telephony will be very greatly increased.

M. I. PUPIN

THE CALORIMETER AS THE INTERPRETER OF THE LIFE PROCESSES[1]

SHORTLY after the outbreak of the present war a scientific commission in Berlin reported that the quantity of energy units required during a year by 68,000,000 inhabitants in Germany amounted to about 57 thousand million calories, and that under changed conditions of dietary habits 81 thousand million calories would be available. In accordance with the requirements of the crisis the habits of the people were changed.

Our own Commission for Relief in Belgium forwarded food on the basis of the knowledge that 1,000 calories in cornmeal cost 11 mills, in wheat 14 mills, in rice 18 mills, in wheat flour 20 mills, in beans 29 mills, and in pork "fat backs" 28 mills.

All this was the world's recognition of the need of fuel for the life processes in human beings.

Rubner's work has made it possible to picture the energy liberated in various forms of living things. Thus Rubner estimates that a horse requires 11 calories per kilogram per day in order to maintain the normal life processes and for the fulfilment of the same necessities a man requires 30 calories per kilogram of body weight, a newborn mouse weighing one gram requires 654 calories per kilogram while a yeast cell weighing 0.000,000,000,5 gr. produces 1,743 calories per kilogram of substance, this also being the heat produced by a kilogram of diphtheria bacilli. The energy production in these lower forms of life was measured by determining the rise in temperature of the medium in which they lived when this was confined within the limits of a Dewar flask. The heat production of a kilogram of yeast thus measured was three fold that found for the same unit of mass

[1] Read at the New York meeting of the National Academy of Sciences, November 16, 1915.

in a newborn mouse, 58 times that of a man and 157 times that of a horse.

Although these values appear to be extremely variable, there is one unit of measurement which in mammalia is quite constant and that is the heat production per square meter of surface. Bergmann, in 1848, was the first to advance this hypothesis and a year later the French observers Regnault and Rieset stated that the heat production of sparrows per unit of weight was ten fold that of fowls, a phenomenon which they asserted was due to the fact that the smaller animals present a relatively larger surface to the surrounding air and thereby experience a considerable chilling, with the consequent generation of sufficient heat to maintain the normal body temperature. In 1883, Rubner published calculations which showed that the heat production of mammalia of various shapes and sizes was the same per square meter of surface. Figures are given such as 1,042 calories for man, 1,039 for the dog and 1,122 calories for the new-born mouse per square meter of surface during periods of 24 hours when the temperature of the environment is 15° C. and when moderate voluntary movements are permitted.

Further analysis showed Rubner that this evenness of heat production per unit of body surface was not due to any relation between the area of body surface and the area of cell surface within the organism. There are in one kilogram of body weight of man 150.2 square meters of such surface and each square meter of cell surface produces 0.2 calories per day. In the new-born mouse each square meter of cell surface produces eleven times this amount or 2.2 calories. It is of interest, also, to note that a kilogram of yeast cells presents a surface area of 600 square meters and at a temperature of 38°, or that at which mammalian cells exist, 1.25 calories per

square meter of surface are produced in 24 hours, 8.34 grams of cane sugar undergoing inversion and fermentation during that interval. This reaction is independent of the strength of the sugar solution within the wide limits of 2.5 to 20 per cent. If the strength of the solution be at the maximum of normal reaction, or twenty per cent., the quantity of sugar utilized in twenty-four hours would be contained in a film 4/100 of a millimeter in thickness surrounding the cells. A like analysis shows that in man whose cells are bathed in a medium containing 0.1 per cent. of sugar the quantity necessary for the support of life during one day would be contained in a layer which if spread around the cell would be 5/100 of a millimeter in thickness.

From the calculation of the energy requirement in the food for the life of a nation to the energy liberated by a yeast cell in its simple resolution of sugar into alcohol and carbon dioxide is indeed a far cry, except as showing that the energy doctrine, as enunciated by Rubner, unites the world of living things.

In 1912 I calculated that the heat production of three quiet and sleeping dogs was 759, 748 and 746 calories per square meter of surface at an environmental temperature of 26°, that a dwarf produced 775 calories per square meter of surface, and that four out of five sleeping men investigated by Benedict showed an average heat production of 789 calories per unit of area. Only in the sleeping infant 7 months old investigated by Howland, did the metabolism appear out of the ordinary and reached a level of 1,100 calories, and this factor was specifically pointed out as indicating a higher metabolism in the youthful protoplasm than is present in the adult.

When the Russell Sage Institute of Pathology constructed in Bellevue Hospital an Atwater-Rosa calorimeter copied in the main after the successful models of Benedict, it became absolutely essential that some criterion of normal metabolism be established, as a basis from which one could estimate whether the metabolism of a patient under investigation was higher or lower than the normal. The severe criticisms of Benedict upon the method of estimating heat production from the unit of surface led to a very careful review of all the evidence and to new experiments. Du Bois, who took up this work, has used an accurate and ingenious method with which he has been able to actually measure the surface area of normal men. He and Mr. Delafield Du Bois have discovered that the formula heretofore used for estimating the surface area in man showed an average inaccuracy of 16 per cent. and a maximal variation from the normal of 36 per cent., this being found in very fat individuals. A new formula has been evolved which gives an average variation of ± 1.5 per cent. and a maximal variation of ± 5 per cent. Using the older formula of Meeh, the heat production per square meter of surface is 833 calories during 24 hours, but using the more accurate formula of Du Bois that rises sixteen per cent. to 953 calories. In normal adults of various shapes and sizes this is the *basal metabolism* as measured when the individual is resting and before the administration of food in the morning. The variation from this standard does not exceed 10 per cent. in 90 per cent. of the cases. The maximal variation is 15 per cent.

The critical studies of F. G. Benedict have been especially helpful in stimulating the reconsideration of all the data and methods in relation to this subject. Benedict is in agreement with Carl Voit when he concludes that the mass of active proto-

plasmic tissue determines the height of the metabolism. However, in the search for a standard upon which to calculate what would be the normal heat production of a man suffering from disease it is obviously impossible to measure the mass of active protoplasmic tissue. It is, therefore, most fortunate that the unit of surface area eliminates the same amount of heat in the normal adult within ten per cent. of a determined average.

The reason for this is not clear, but the fact is established. It is known that a regulating mechanism maintains the body temperature at a fixed point, though the reason for this is also undetermined.

The figures given hold true for the adult but are subject to variations due to age.

Murlin has pointed out that the newborn baby has a distinctly lower metabolism than normal and that this rapidly rises during the first year to a standard above the normal. It should be remembered in the first place, that the newly born may be considered in the light of an internal organ which has been protected from external stimuli. This is indicated by the work of Murlin upon the pregnant dog and from that of Murlin and Carpenter upon the human mother. The increase in heat production during the first months of the infant's life may be due to the union of the muscles with medullated nerve fibers. Furthermore, one finds on analysis that there is 24 per cent. of muscle tissue in the newly born baby as against 42 per cent. or nearly double that quantity in the adult. These proportions are reversed as regards glandular tissue, there being 47 per cent. of this tissue in the newborn and only 24 per cent. in the adult. It is this preponderance of glandular tissue in early life that may be the cause of the prevalence of the higher metabolism during the early period of growth. Du Bois has found that in a

number of boys just before puberty the heat production is 25 per cent. above the normal and it is interesting to query whether this be due to glandular activity.

With the approach of old age the metabolism falls about ten per cent.; there is no longer quite the same intensity of oxidation as at the height of a man's virility.

In conditions of disease, as in those of health, the same materials, such as protein, fat and carbohydrate are oxidized and in the normal fashion, and they produce heat after the normal manner. The disease of diabetes presents a striking exception, as sugar may here remain unoxidized. In general, one may say that the intensity of the metabolism processes are little affected in many diseased conditions. In diabetes the heat production does not rise appreciably above the normal. The calorimeter in the hands of Du Bois and his fellow worker has shown that in severe anemias and in heart disease involving dyspnea, the heat production may increase. This is very probably due to the stimulus of lactic acid, a similar phenomenon being witnessed in a dog poisoned with phosphorus. In a typical fever such as typhoid the heat production may increase between 40 to 50 per cent. and in severe cases of exophthalmic goiter it rises to between 75 to 100 per cent. above the normal. It is fortunate that the ingestion of food which in the normal individual causes an increase in heat production, does not abnormally stimulate the fires of metabolism in these patients already suffering from intensified oxidation processes.

The inner process of heat production involves the interplay between the living cells of the body and the nutrient constituents of the fluids which bathe them. It has been known since the time of Lavoisier that the ingestion of food results in an increase in metabolism. In the presence of

abundant food the cells produce heat in increasing measure. Thus, after giving meat alone in large quantity to a quietly resting dog the heat production may be double that of the normal basal metabolism. The constituent amino-acids of protein are relieved of their NH_2 groups and the denitrogenized remainders are utilized for heat production, any excess being converted into glucose and retained in the organism as glycogen. The great rise in heat production is in large measure due to the direct chemical stimulation of the cells through the metabolism products of certain amino-acids. The proof of this lies in the fact that if glycocoll or alanine be given to the diabetic dog the heat production is largely increased, although these substances are not oxidized and there is therefore no evolution of heat from them, for they are converted into glucose and urea which appear in the urine. When the same method is applied to the study of the sugars, it fails to support the idea that the intermediary products of sugar metabolism directly stimulate the cells to a higher heat production. Thus, fructose administered to a diabetic dog caused no increase in heat production, although it underwent chemical change, for it was found as glucose in the urine. Since all the evidence regarding this reaction points to a preliminary cleavage of fructose which contains six carbon atoms into two molecules each containing three atoms of carbon and to the subsequent synthesis of these molecules into glucose, one may reason that the preliminary cleavage products of carbohydrate metabolism are not direct stimuli to protoplasm, as are those of amino-acids like glycocoll and alanine, but that normally the mere presence of a large number of metabolites of sugar results in their oxidation in increased measure.

Rubner has shown that when the yeast cell is bathed in a solution of sugar and peptone the protein is used for growth or cell repair only, while alcoholic fermentation furnishes the energy, and as before stated the quantity of this energy is independent of the strength of the solution. So also in a mammal such as the dog, if one give 50, 70 or 100 grams of glucose, the energy production increases in all cases to a level of about 30 per cent. above the normal. It appears that the cells by a process called "self-regulation" use the fragments of broken glucose up to a certain limit which is not transcended. Any excess of these fragments is converted into glycogen or into fat, a small quantity of energy being absorbed in the first process and a small quantity being liberated in the second. The result of this is that beyond a certain limit of carbohydrate plethora, the heat production in the dog scarcely rises, and this is analogous to the behavior of the yeast cell towards its nutritive environment.

The study of the intermediary metabolism upon which the total heat production of an animal is based, furnishes a fascinating field for the scientist, and it is also evident that the study of the fuel requirement of the human individual in health and in disease presents many problems of importance for the general welfare of the community at large.

<div align="right">GRAHAM LUSK</div>

OBSTACLES TO RESEARCH[1]

THE duty of the university to investigate the unknown as well as to teach the known is clearly evident. In the performance of this duty, the importance of research work is emphasized in many ways. Promise of productive scholarship is a leading qualification demanded in selecting members of the faculty. Encouragement and facilities for original

[1] An address delivered before the Minnesota Chapter of the Sigma Xi Society, October 21, 1915.

work are freely provided. And yet we must confess that the outcome, broadly speaking, is somewhat disappointing, both here and in other universities. It is true that the results in some departments and in many individual cases are satisfactory. On the whole, nevertheless, considering our great opportunities, we seem to add relatively little to the sum total of human knowledge. Why? A recognition of the obstacles to research might enable us in some measure to overcome them. At any rate, the problem is worthy of our earnest and careful consideration.

Let us consider the problem from the biological point of view. The accomplishment of every human being (as of all living things) is the resultant of two factors: heredity and environment. In research work, as in all other lines of activity, the *limits* of possible achievement for each individual depend upon his innate talent, established through heredity. Within these limits, however, the *realization* of possibilities is conditioned by the environment. We must therefore distinguish clearly between (possible) capability or capacity and (actual) accomplishment in the field of original investigation.

The first and most important obstacle in research work is accordingly the limitation of capacity, which is determined by heredity. Since it is now too late to quarrel with our ancestors concerning the matter, as individuals we may as well recognize this as an insurmountable obstacle. From the broad university point of view, this fundamental obstacle may be partially removed by great care in the selection of faculty members. Geniuses are scarce, however, and competition for them very strong; so it is inevitable that even in the strongest universities the faculties must be made up of men with varying degrees of innate talent.

But while our heredity is beyond our control, our environment is not. At least we can modify the environment to a considerable extent. And this is a fact of tremendous practical importance. After all, environment does play an important part in determining both the quantity and the quality of our per-

formance in all lines, including research work. If the environment is sufficiently unfavorable, even the highest genius is sterile. Of two men with equal native ability, one with better opportunity may be far more richly productive than the other. It is a case of seed and soil. The result is determined by heredity plus environment; or perhaps better, heredity *times* environment.

Geniuses are sometimes able to accomplish a great deal, even in a relatively unfavorable environment; but fortunately research work is not a province reserved exclusively for genius. It is encouraging to most of us to remember that the army of investigation requires private soldiers, as well as officers of various grades. Even moderate capacity does not preclude research work of real value. As expressed by John Hunter:

A man with a sufficient fund of knowledge, and a close application to one art or science, will make great improvements in it though his talents may not be the best; or, in other words, though he be not a great genius.

Conquering the unknown in the field of knowledge is somewhat like civilization invading a new territory. A few bold and talented explorers may lead the way and blaze out new paths in the wilderness; but their excursions would be fruitless unless followed up by pioneer settlers, who by arduous labor develop the country and render its resources available for mankind. Moreover, even the explorer is in many ways largely dependent upon the knowledge and equipment furnished by others, his predecessors and his supporters.

Likewise, in the exploration of the field of knowledge, there is work for all. The history of science abundantly proves that brilliant discoveries and important generalizations usually rest upon a long series of accurate observations, requiring care and patience, but not great genius. A classical example is that of Kepler's laws of planetary motion, founded upon the extensive astronomical observations by Tycho Brahe. In biology, to substantiate and support the cell-doctrine of Schleiden and Schwann, and the doctrine of organic evolution of Darwin, has required an immense

amount of patient labor by a multitude of observers during the past century. Other examples could easily be cited in various fields. The plodders as well as the geniuses should receive their due share of credit for the progress of science.

The production of research work of merit is thus within the capabilities of every one worthy of membership in a university faculty. Doubtless some who are talented predominantly as teachers should devote themselves chiefly to this field, and others are especially fitted for administrative work; but it is desirable that every one should participate to at least a slight extent in research work. As a matter of fact, we may go still further in urging that the *spirit* of scientific research should pervade *all* education, from the kindergarten to the university. Mankind in general is still far from appreciating the fact that the method of science is not a mysterious gift of genius, but a practical tool in the discovery of facts and in their application to the problems of everyday life. As Professor Remsen so aptly expressed it in his address at the dedication of the chemistry building of the University of Minnesota last year, the scientific method is essentially this: "First study the facts; then draw your conclusions from them."

From this point of view, all our problems thus become research problems; and education is able to teach us how to solve them efficiently in proportion to the extent to which training is provided in the methods of original investigation. Thus all education should provide training in scientific research, differing in degree rather than in principle as we pass from elementary to higher education. President Hill (in a recent commencement address at the University of Minnesota) has well said that "The teacher should arouse the spirit of discovery as the first step in the process of learning." A more general recognition of the significance of scientific research for education, a correction of the prevalent error that research is a matter concerning only a chosen few, would remove an obstacle which prevents a more generous support of higher scientific investigation.

While all instruction should be permeated with the research spirit, a conscious effort should be made, especially in the university, to single out as early as possible those students showing unusual talent for original work, and to give them particular aid and encouragement. We must constantly emphasize the necessity for recognition of unusual talent, since otherwise our entire time and energy will tend to be exhausted in caring for the larger number representing mediocrity. This subject is well discussed in a recent report of the subcommittee on the selection and training of students for research (Committee of One Hundred of the American Association for the Advancement of Science), published in SCIENCE, September 17, 1915.

It is, however, not my present purpose to consider the message of science for education in general, but rather to discuss the specific obstacles met by university workers in the field of original investigation. Since we can not change our heredity, possibilities for improvement must be found in the environment. What factors in our environment affect our scientific productivity?

We might classify the environmental factors affecting our research work in two groups: mental and physical. In the first rank, I would place the factors determining our mental attitude toward research. I suspect that investigation lags more frequently from lack of sustained interest than from any other cause. It is doubtless true that one is usually most interested in what one can do especially well. And research ability, as we have already noted, is largely a hereditary matter. Nevertheless, our mental attitude is unquestionably influenced in large measure by the opinion of our colleagues. Appreciation by one's fellows is a most powerful stimulus. Thus a general recognition of good research work will greatly encourage the worker to persist in spite of all obstacles. If Sigma Xi can succeed in establishing a more enthusiastic *esprit de corps* among investigators, it will greatly help the cause of scientific research.

The physical factors affecting research work are also of importance. The obstacles under

this group include lack of material facilities, lack of time and lack of organization. Each of these may be briefly considered in turn.

The material facilities necessary for research include laboratories and equipment of various kinds, supplies, instruments, technical assistants, books, etc. It is customary to cite lack of adequate facilities of this kind to explain shortcomings in scientific productivity. And there is no doubt that more generous provision for these things would greatly facilitate many lines of research work. But, generally speaking, I believe that this factor is somewhat overrated. The man who does nothing because facilities are inadequate would usually accomplish but little even with unlimited resources. On the other hand, the man whose heart is in his research work will rarely fail to secure adequate support, if he perseveres and demonstrates his interest and capability.

Inadequate support of research work is sometimes ascribed to lack of appreciation on the part of university administrative officers, who control the purse-strings. This is usually an unjust accusation. University officers as a rule are keenly anxious to encourage and support research work, but they in turn are always more or less hampered by financial limitations. With the present evidently increasing popular interest in and appreciation of scientific work, however, we may confidently expect in the future more generous provision of funds available for this purpose. Even the "man in the street" can see how Germany has increased her efficiency by systematic encouragement of scientific research. America is likewise beginning to realize that this is not a luxury but a necessity, for which generous support must be provided.

Even more than lack of facilities, lack of time is an obstacle very frequently encountered by university research workers. Many university men are carrying a burden of routine teaching which, if well done, must greatly encroach upon the time absolutely essential for serious research work. In many cases, a considerable amount of routine administrative duties, committee work, etc., is added. Under these conditions, which shall be neglected—

teaching, administrative work, or research? Or should one risk the danger of overwork by trying to keep up with all? Surely this is a question hard to answer. The proper solution is of course to provide a sufficient staff to handle the routine teaching and administration, and at the same time leave adequate time free for research. In a rapidly growing university, however, it is difficult to make this provision. But conditions are improving in this respect, and comparatively few men are so overburdened with routine work as to preclude a reasonable amount of time for research.

Lack of time for research work is often due not so much to the actual amount of other work as to waste of time. By carefully planning our university work, much time could be saved. There is too much "scatterment." All too frequently we allow minor routine duties to break in at all times. These minor details should be concentrated so far as possible at certain designated periods, so as to leave uninterrupted consecutive time free for research. A set of office-hours established and rigidly kept will gain a surprisingly large amount of time otherwise frittered away. Thus one serious obstacle to research may be readily removed.

Finally, I believe that another obstacle of importance in many cases is the lack of a proper organization of the research work itself. For the best results, careful, systematic planning is necessary. Too often investigation is taken up in a haphazard sort of way, which is likely to result in failure. While no rule can be made which will apply to all cases, it is certainly true that the topic to be investigated should be carefully considered before the work is undertaken. The literature should be scanned sufficiently to make sure that the contemplated problem has not already been solved, and to render available the experience of others in similar fields. Work should not be undertaken until the necessary facilities are assured to carry it through. In general, a broad fundamental problem of which successive phases may be worked out through a series of years will prove more profitable than a num-

ber of shorter, unrelated subjects of investigation. Wherever possible, cooperation with one's students or colleagues in research will usually yield better results, from the standpoint of economy in time and cost, than will individual efforts. Such matters may seem self-evident to some and trivial to others; but I feel sure that in many cases more attention to them would be well worth while. In short, system is as necessary for efficiency in research as in any other kind of work.

In conclusion, the main points may be emphasized as follows: Obstacles to achievement in research are due partly to inherent or hereditary limits of capacity, and partly to environmental factors. The latter, which are to some extent within our control, include factors determining the mental attitude, which is of primary importance. The remaining factors include the material facilities, increased support for which depends chiefly upon better appreciation by the public of the value of scientific work. Lack of time is often another important obstacle, which in part may be overcome by a more economic arrangement of routine duties. Finally an obstacle in many cases is the lack in the research work itself of systematic planning and organization, which is necessary for the highest efficiency.

C. M. JACKSON

INSTITUTE OF ANATOMY,
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DR. CHARLES FREDERICK HOLDER

THE love of nature is so deeply planted in our hearts that even those who have passed most of their lives in the artificial atmosphere of cities respond quickly and warmly to the appeal made by scenic beauty and by the variety and charm of plant and animal life. Hence he who can successfully voice these sentiments and satisfy the desire for a better knowledge of the life, habits and instincts of the denizens of wood, vale and stream, is sure of wide recognition and appreciation.

It can safely be said that no one in our land has more perfectly realized these conditions than the late Dr. Charles Frederick Holder, who passed away on October 10, 1915, in his home at Pasadena, California. At once an enthusiastic sportsman and an enemy to all indiscriminate destruction of animal life, he possessed a rare blend of qualities sometimes regarded as incompatible one with the other. Something of his repugnance to the reckless slaughtering of animals characteristic of too many hunters, may possibly have been due to the fact that he came of stanch Quaker stock, one of his direct ancestors, Christopher Holder, having founded, in 1656, the first society of Friends in America.[1]

Charles Frederick Holder was born in Lynn, Massachusetts, August 5, 1851, and received his early education in the Friends' school at Providence, Rhode Island, and in Allen's preparatory school at West Newton, Massachusetts, as well as from private tutors; later on he developed an inclination toward naval life, and in 1869 entered the United States Naval Academy at Annapolis, but did not pursue the course there up to graduation. From his boyhood he showed the taste for hunting and fishing, and at the same time for the study of the habits of birds and fish, that was destined to grow with his growth and become the aim and pleasure of his life.

In 1871, though but twenty years old, he became assistant curator of the American Museum of Natural History in New York City, and held this position until 1875. The present writer cooperated with Dr. Holder for nine weeks in packing up the 1,000,000 specimens of the James Hall paleontological collection in Albany, prior to their transfer to the American Museum of Natural History in New York City. His marriage to Miss Sarah Elizabeth Ufford, of Brooklyn, took place November 8, 1879.

That one so devoted to nature study and to sport should be attracted toward California, especially toward southern California, can be easily understood; however, ill health was the determining cause of Dr. Holder's removal in 1885 to that state, where he established his

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[1] This is related in Dr. Holder's interesting book, "The Holders of Holderness, or Pioneer Quakers."

residence in beautiful Pasadena, California's "Crown City." Here he carried on the literary work that had long taken up the greater part of his time, his numerous publications, both books and magazine articles, treating almost without exception of the beauties and mysteries of animate nature. His enthusiasm for his favorite theme and his happy facility in expression, combined to make the perusal of his books and papers both a pleasure and a stimulus for his many readers, as well in this country as abroad.

His influence in Pasadena, both social and educational, was felt and gratefully recognized by his fellow-citizens. He was chosen president of the local board of education, and a trustee both of Throop College of Technology and of the normal school, and was honorary curator of the college museum. From this institute he received a call to fill the chair of zoology, but did not accept. However, shortly before his death, he was appointed professor emeritus of the Charles Frederick Holder chair of zoology, the foundation of which was due to the instrumentality of his lifelong friend, advisor and encourager, Dr. George E. Hale, director of Mount Wilson Observatory. The income of the $50,000 raised for this foundation, goes, after Dr. Holder's death, to his widow for her lifetime.

All movements for the protection of animal life found in him an ardent supporter, whether as member of a society or as its presiding officer. He was long a member of the American Scenic and Historic Preservative Society, and in the Wild Life Protection League of America he was president of the department of southern California; he also belonged to the National Conservation Society, the American Game Protective and Propagation Association, the American Fisheries Society, and was president of the Los Angeles Society for the Protection of Game. He held the office of vice-president in the Audubon Society of California and in the Los Angeles Zoological Society. On the other hand, as a sportsman he has the credit of being the first to catch a leaping tuna, weighing over 100 pounds, with rod and reel, so that the catch was a legitimate result of a contest between a fisherman's skill and the strength and activity of his eventual victim. The rod used on this occasion is still to be seen at the Tuna Club on Catalina Island, of which Dr. Holder was the founder, his pen having been the most potent factor in making the island and its neighboring waters a favorite resort for fishermen. With Dr. F. F. Rowland he founded the "Tournament of Roses," one of Pasadena's great attractions.

Socially he was one of the most genial and sympathetic of men. He thoroughly enjoyed social intercourse with those whose interests were like his own, and was ever ready to aid them in realizing their aims. The leading social club of Pasadena, the Valley Hunt Club, was founded by him, and he was a member of the Twilight Club of that city. Other clubs to which he belonged as member, or honorary member, were: Sunset Club of Los Angeles, Tarpon Club of Texas, Aransas Pass Tarpon Club, South California Rod and Reel Club, Authors' Club of London, Sea Anglers' Club of Glasgow, British Sea Anglers' Society of London, Fly Fishing Club of London, Casting Club of Paris. In 1911 the Académie des Sports of Paris awarded him a gold medal. In a field less exclusively his own, he was a member of the New York Academy of Sciences, of the National Geographic Society and the Linnæan Society.

It is impossible to do more than mention a few of the more notable publications of Dr. Holder, as, for example, "Elements of Zoology" (1885), "Living Lights" (1887), "Louis Agassiz, his Life" (1892), "Along the Florida Reef" (1892), "Stories of Animal Life" (1900), "Half-Hours with Nature" (1901), "The Log of a Sea Angler," "Life and Sport in the Open in Southern California," "Big Game Fish at Sea" (1873–76). Among his almost innumerable magazine papers were a series of articles in *Forest and Stream*. This represents but a fraction of the literary work of one who by precept and example furthered the true interests of sport, and aroused and fostered in a large circle of readers a taste for the observation and study of nature.

The funeral services took place at his late residence, 475 Bellefontaine Street, Pasadena, the Rev. Robert Freeman officiating. There were present to do honor to his memory many prominent people from all parts of southern California. The active pallbearers, selected from among the intimate personal friends of Dr. Holder, were: C. D. Daggett, Dr. Francis F. Rowland, Walter Wotkins, Walter Raymond, William R. Staats and A. Stephen Halsted. Notable among the many letters of condolence received by Mrs. Holder, was a warm tribute of regard from Gifford Pinchot, who was in strong sympathy with Dr. Holder's tireless work in behalf of the conservation of wild life in our land.

GEORGE F. KUNZ

SCIENTIFIC NOTES AND NEWS

OFFICERS of the Royal Society were elected at the anniversary meeting on November 30 as follows: *President,* Sir J. J. Thomson in succession to Sir William Crooks; *Treasurer,* Sir A. B. Kempe; *Secretaries,* Professor A. Schuster and Mr. W. B. Hardy; *Foreign Secretary,* Dr. D. H. Scott; *Other Members of the Council,* Professor J. G. Adami, Sir T. Clifford Allbutt, Dr. F. F. Blackman, Dr. Dugald Clerk, Sir William Crookes, Professor A. Dendy, Professor J. Stanley Gardiner, Dr. H. Head, Mr. G. W. Lamplugh, Professor A. E. H. Love, Major P. A. MacMahon, Professor A. Smithells, Professor E. H. Starling, Mr. R. Threlfall and Sir Philip Watts.

M. MAURICE CAULLERY, professor of organic evolution in the University of Paris and president of the Zoological Society of France, has been appointed to be exchange professor from the French universities at Harvard University and will lecture at Cambridge during the second semester.

CHARLES CLARK WILLOUGHBY has been appointed director of the Peabody Museum of American Archeology and Ethnology of Harvard University.

AT the annual dinner of the Geographic Society of Chicago, which will be held in the Congress Hotel on January 8, the gold medal of the society will be presented to General William C. Gorgas.

DR. ERNST EHLERS, professor of zoology at Göttingen, has celebrated his eightieth birthday.

THE prize of the Martin Brunner foundation in Nürnberg has been awarded to Dr. Jakob Wolff, of Berlin, for his work on cancer.

ON November 23 at Aberdeen, S. D., the South Dakota State Academy of Science was organized with the following officers:

President, H. I. Jones.
First Vice-president, E. A. Fath.
Second Vice-president, O. R. Overman.
Treasurer, A. Mahre.
Secretary, R. J. Gilmore.

The meetings of the organization are held at the same time and place as the State Educational Association.

AT the annual meeting of the American Association of Clinical Research, held recently in Philadelphia, the following officers were elected: *President,* Dr. Coleman, of New York City; *First Vice-president,* Dr. William B. Snow, of New York City; *Second Vice-president,* Dr. Leon T. Ashcraft, of Philadelphia. Dr. James Kraus, of Boston, is *Permanent Secretary* of the organization.

AT the annual meeting of the Faraday Society, London, Sir Robert Hadfield was elected president.

THE following, as we learn from *Nature,* have been elected officers of the Cambridge Philosophical Society for the ensuing session: *President,* Professor Newall; *Vice-presidents,* Dr. Shipley, Dr. Fenton, Professor Eddington; *Treasurer,* Professor Hobson; *Secretaries,* Mr. A. Wood, Dr. Arber, Mr. G. H. Hardy; *New Members of the Council,* Dr. Bromwich, Dr. Doncaster, Mr. C. G. Lamb, Dr. Marr, Mr. J. E. Purvis.

THERE is also given in *Nature* the list of officers elected at the anniversary meeting of the Mineralogical Society which follows: *President,* W. Barlow; *Vice-presidents,* Professors H. L. Bowman, A. Hutchinson; *Treasurer,* Sir William P. Beale, Bart.; *General Secretary,* Dr. G. T. Prior; *Foreign Secretary,*

Professor W. W. Watts; *Editor of the Journal,* L. J. Spencer; *Ordinary Members of Council,* Dr. J. J. Harris Teall, F. N. Ashcroft, Professor H. Hilton, A. Russell, W. Campbell Smith, Dr. J. W. Evans, Dr. F. H. Hatch, J. A. Howe, T. V. Barker, G. Barrow, Dr. C. G. Cullis, F. P. Mennell.

Dr. W. F. M. Goss, dean of the College of Engineering of the University of Illinois, has made a final report to the Chicago Association of Commerce on his investigation in railroad smoke abatement. With this report Dean Goss finished his labors as chief engineer of the expert commission that was appointed five years ago, after having devoted two years to it, being on leave of absence from the university in order to serve the commission.

The annual gardeners' banquet in St. Louis, provided for in Mr. Shaw's will, was held on November 19 at the Liederkranz Club. Mr. John K. M. L. Farquhar, of Boston, president of the Massachusetts Horticultural Society, and past president of the Society of American Florists and Ornamental Horticulturists was the speaker of the evening.

Dr. Joseph E. Pogue, associate professor of geology and mineralogy of Northwestern University, will lecture before the Geographic Society of Chicago on December 16, his subject being "Through the Heart of Colombia."

At the recent National Conference on Marketing and Farm Credits held in Chicago, Dr. F. H. Newell, head of the department of civil engineering at the University of Illinois, gave an address in which he urged the adoption of a system of rural credits which would meet the needs of farmers operating irrigated lands.

The Long Fox lecture was delivered by Dr. Richardson Cross, at the University of Bristol, on December 1, on "The Evolution of the Sense of Sight."

The untimely death of Mr. Chas. F. Adams, well-known physics teacher of Detroit (October 29, 1914), has been the inspiration for many to join in a college scholarship fund in his honor. The Charles Francis Adams Memorial Scholarship Fund raised by citizens, teachers and former students, now amounts to $1,300, but it is expected will reach $1,500. Mr. R. V. Allman, former instructor in the University of Michigan, succeeds Mr. Adams. The Detroit Central High School is one of the pioneers giving a full year's junior college work in biology, chemistry, physics and languages, now accepted by the University of Michigan.

The medical staff and patients of the Workmen's Circle Sanatorium, Liberty, have adopted resolutions regretting the death of Dr. Edward Livingston Trudeau, who had for thirty-one years worked untiringly and unselfishly in the interest of the consumptive workingmen and women, and expressing their appreciation of his work by conferring on the hospital building of the Workmen's Circle Sanatorium, the name "Trudeau."

At a meeting of the directors of the Washington Association for the Prevention of Tuberculosis, resolutions were drafted paying tribute to the unselfish character of General George M. Sternberg, late president of the association, and to his valuable contributions to preventive medicine.

Orville Adelbert Derby, distinguished for his work in geology, died by suicide in Rio Janeiro, on November 27. He had been chief of the geological survey of Brazil since 1907 and previously since 1875 connected with the survey and the National Museum, except for two years when he was instructor in Cornell University. He was born in New York State in 1851.

Dr. Charles Callaway, of Cheltenham, who was one of the pioneers in the study of the Archæan rocks of the British Isles, has died at the age of seventy-seven years.

Nature records the death, in his eighty-sixth year, of Mr. Charles Fortey, who was for many years honorary curator of the Ludlow Natural History Society's Museum.

Mr. J. Sinclair, author of works on stockbreeding and agriculture, died on November 5 at the age of sixty-three years.

THE death is announced of Dr. C. J. Bouchard, emeritus professor of pathology in the University of Paris.

ALL persons who intend to present papers before Section E, geology and geography, of the American Association for the Advancement of Science, at the Columbus meeting, should submit title of paper and abstract to Professor George F. Kay, Iowa City, Iowa.

A NEW method of manufacturing sulphuric acid, for which advantages are claimed, is suggested in United States Department of Agriculture Bulletin No. 283, "The Production of Sulphuric Acid and a Proposed New Method of Manufacture." The essential difference of the method is that the gases employed are drawn downward through a spiral flue in place of being drawn through lead chambers or intermediate towers. It is asserted that the resistance of gases to the downward pull and the constant change in their course through the spiral tend to mix them very intimately. The fact that the gases constantly impinge on the walls of the spiral flue, which can be cooled either by air or water, makes it practicable to maintain the gases at a temperature most favorable for the efficient yield of sulphuric acid. In laboratory tests in which the spiral was utilized, practically all the sulphur dioxid was oxidized to sulphuric acid, only traces being lost through escape or in the system. The lead spiral, the author points out, however, is not intended to replace the Glover tower, nor to do away with the Gay-Lussac tower. It is believed that while the lead spiral will take considerable lead, the great reduction it will effect in the chamber space will make it possible to construct a plant with considerably less lead than is required in the ordinary chamber system. The new type of plant requires no other device to accelerate the reactions, occupies much less ground space, and would not need as large buildings, and therefore should decrease the initial cost of construction. The method, however, has been tried only on a laboratory scale, and the bulletin refuses to predict just how efficient the

commercial plant would be, but states that all indications are that this method offers promise of being economically successful.

THE area of the Chugach National Forest, Alaska, which is to be crossed by the railroad that the government is building from Seward to Fairbanks, is reduced nearly one half by a proclamation, signed by President Wilson, returning approximately 5,802,000 acres to the public domain. This action follows classification of the land by the Forest Service showing that the areas involved are not of high enough timber value to warrant government protection, and means the largest elimination of national forest land ever made by a single presidential proclamation. The boundaries of the forest, as redrawn by the president's proclamation, now contain approximately 5,818,000 acres, supporting about eight billion feet of merchantable timber. On the area thrown out of the forest there is in the aggregate a large amount of timber, but it is so sparse and scattered as to be of little or no commercial value. The land remaining within the forest, however, contains the largest and most accessible supply of timber for the development of the great mineral fields to the north of Bering River, and is the region in which the Alaskan Engineering Commission has been authorized to cut 85 million feet of timber for use in constructing the government's new railroad. On account of the time required for cutting and seasoning construction timber, the commission has had to purchase some lumber from Washington and Oregon, but as cutting has already commenced on the Chugach, it is expected that the Alaskan timber will soon be serving the needs of the railroad builders. The lands eliminated by the proclamation are in three large tracts; one along the entire southerly slope of the Chugach Mountains, the second lying northeast of Seward, between Resurrection Bay and Kings Bay, and the third, northwest of the Kenai Mountains in the region around Tustamena and Skilak lakes. In addition, the towns of Hope, Sunrise, Kenai and Ninilchek are eliminated. According to the Forest Service, the chance of locating homesteads in the

excluded lands is extremely small, since they contain few agricultural areas, although in some localities there are said to be small patches suitable for farming.

WE learn from *Nature* that the council of the Chemical Society has sent to every fellow a letter directing attention to the government scheme for the organization and development of scientific and industrial research. In accordance with this scheme, a committee of the privy council has been appointed, and also an advisory council of scientific men whose primary functions are to advise the committee of council on—(i) proposals for instituting specific researches; (ii) proposals for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades; (iii) the establishment and award of research studentships and fellowships. The council of the Chemical Society considers it to be the urgent duty of every fellow to render all assistance possible to the advisory council by suggesting suitable subjects for research. As pointed out in the White Paper, the results of all researches financed by public funds will be made available under proper conditions for the public advantage, and the council feels assured that every fellow will place patriotic duty before private gain at such a time. Suggestions for purely scientific researches will be appreciated, but those having a direct bearing on chemical industry and its promotion will naturally receive a preference.

FOLLOWING Secretary Lane's instructions to put special effort into its potash investigations, the United States Geological Survey is publishing the suggestion that a possible source of potash may exist in the tailings piled up at the concentrating mills of the big copper mines in the west. The " porphyry " ores which are being mined by the millions of tons annually contain several times as much potash as copper, and this remains in the tailings at the mills, material already finely ground and in condition for treatment, as well as easily accessible for shipment. This potash, however, is locked up in the form of silicate minerals, and the commercial extraction of potash from

silicates has been for several years the subject of earnest study by industrial chemists. If this problem can be solved, it would appear that a large tonnage of potash-bearing material is available in the Western States. The brief report issued this week by the Geological Survey (Bulletin 620–J) contains typical analyses of these "porphyry" ores from the largest copper camps in a half-dozen states, as well as tonnage estimates of the ore reserves and ore already mined and treated. A few check analyses of tailings are also published. Suggestion of a possible potash reserve in these tailings originated with B. S. Butler, the geologist in charge of the Survey's statistical study of copper, who has based this short paper upon the published analyses of specimens collected by the government geologists in their investigations of the mining districts. The significant fact regarding this possible source of potash is that in quantity it is more than adequate to meet all the needs of the country as measured by present consumption of potash. The problem of potash extraction from this by-product of the copper industry therefore becomes an attractive one for the chemical engineer and mineral technologist.

A PRESS bulletin of the U. S. Geological Survey notes that for many years the origin of the peninsula of Florida has been the subject of speculation among scientists. Some sixty years ago the great naturalist Louis Agassiz advanced the hypothesis that the greater part of the peninsula had been produced during comparatively recent times by successive growth of coral reefs along its southern margin, which has thus been extended farther and farther into the waters of the Gulf. A few years later Joseph LeConte restated his view of the organic origin of Florida and suggested that the work of corals has been largely supplemented by mud and other sediments dropped by the Gulf Stream. This hypothesis was generally accepted as correct for many years, but in 1881 Professor Eugene A. Smith discovered that the greater part of the peninsula of Florida is underlain at no great depth by limestones which are not the work of corals and which were formed long before the Re-

cent epoch. For the last thirty-four years these fundamental rocks of Florida, often called the Ocala limestone, have been thought to be nearly equivalent in age to the Vicksburg limestone of Mississippi and Alabama and have been called the Vicksburg group. A short time ago C. Wythe Cooke, of the Geological Survey, discovered that the Ocala or so-called Vicksburg limestone of Florida contains many fossil remains of sea shells of the same species that occur in the marls near Jackson, Miss., and that are known to have become extinct before the rocks at Vicksburg were deposited. It therefore appears that the Ocala limestone is of about the same age as the Jackson formation and is considerably older than has heretofore been supposed. Instead of being of recent origin, as was thought by Agassiz and LeConte, the Floridian plateau was in existence during the Eocene era—probably two million years ago. A copy of Mr. Cooke's paper on the age of the Ocala limestone, which is technical and intended mainly for the use of professional geologists, will be sent free on application to the Director, United States Geological Survey.

UNIVERSITY AND EDUCATIONAL NEWS

MRS. RUSSELL SAGE has given Syracuse University a fund to build a college of agriculture as a memorial to her father, Joseph Slocum. The building is to cost several hundred thousand dollars, the exact sum to be decided later. The site for the building is to be determined at a meeting of the university trustees, December 14. Construction will be started early in the spring.

A NEW building will be constructed for the University of Illinois Medical School in Chicago for the clinical courses. The initial cost is to be about $100,000, which will pay for one wing. This will be added to later as the demand for room increases.

THE trustees of Delaware College have made plans for the expenditure of a gift of $500,000 to the college by an unnamed donor. A report submitted by H. Rodney Sharp, chairman of the Plans and Development Committee, which was approved by the board, showed that $250,-000 will be used for a science hall to house the agricultural and chemical departments, $75,-000 to remodel the old dormitory building and turn it into a commons for the students, and $200,000 will be set aside for maintenance.

FIRE early on December 7 destroyed the Thompson chemical laboratory of Williams College, a three-story brick structure, loss of which is estimated at $100,000. The fire started in a workroom on the first floor from spontaneous combustion, according to the college authorities and quickly spread through the building.

WARSAW UNIVERSITY and Warsaw Observatory have been transferred by the Russians to Rostow-upon-Don. At the same time the German government has reestablished the University of Warsaw, and added a faculty of medicine. Dr. von Brudsynski has been appointed rector, and Professor Wilhelm Paszkowski, in charge of the academic information bureau at Berlin, has been sent to Warsaw to advise on the reorganization of the university.

DR. EDWIN B. CRAIGHEAD, whom the state board of education failed to reelect as president of the University of Montana, has been elected commissioner of education of the State University of North Dakota. The three professors of the University of Montana which the board of education failed to reelect, Professor Mary Stewart, dean of women, Dr. T. B. Bolton, professor of psychology, and Dr. G. F. Reynolds, professor of English, have been reelected. They have, however, been given leave of absence for the coming year.

DR. WILLIAM OPHÜLS, professor of pathology, has been appointed acting dean of the Stanford University Medical School, in place of Dr. R. L. Wilbur, whose term as president of Stanford University begins January 1, 1916.

AT the University of Kansas, Dr. C. H. Ashton has been promoted from an associate professorship to a full professorship of mathematics.

Miss Gertrude I. McCain has been appointed professor of mathematics in the Western College for Women, Oxford, Ohio.

DISCUSSION AND CORRESPONDENCE

A REMARKABLE ECLIPSE

To the Editor of Science: Eclipses of the sun and moon occur with such frequency and are so similar in character and appearance that a distinction between them sufficiently great to be noticed by the uncritical observer would seem to be out of the question. The cause of eclipses is well known, and as they may be easily calculated the times of their occurrence and nature of their appearance are always published in the Nautical Almanac two or three years before they actually take place. Total eclipses of the sun have for many years afforded the necessary darkness for observing the heavens in close proximity to the sun; and numerous expeditions have been sent to distant parts of the earth in order to take advantage of the few moments of additional darkness thus afforded; and much interesting and useful information concerning the physical constitution of the sun has been obtained in this manner. At the present time, however, the chief importance of eclipses lies in the opportunities they afford for testing the accuracy of the calculations of mathematicians, and the correctness of the physical theories on which such calculations are based; and for this purpose the distinction between partial and total eclipses is of little importance.

In the year 1915 there were only two eclipses, both of the sun. The first occurred on February 13 under ordinary circumstances; the central eclipse began at sunrise in the Indian Ocean a few degrees to the southward of the island of Madagascar; passing along the northwestern coast of Australia, it crossed the island of New Guinea and ended at sunset in the North Pacific Ocean. The second eclipse took place on August 10; beginning at sunrise a few degrees to the southward of the Japanese Islands in the North Pacific Ocean. It moved to the eastward a few degrees southward of the Sandwich Islands at noon, and ended at sunset in the South Pacific Ocean. These two eclipses were very similar in character in so far as outward appearances are concerned. Their relative importance arises from the very dissimilar conditions under which they took place. In the eclipse of August 10 the centers of the *sun, moon* and *earth* were very nearly *in the same straight line.* I have examined the record of all the eclipses that have taken place since the year 1767; and I find that in the year 1903 there were two very similar eclipses; one of which took place on February 21 and the other on August 17 of that year.

It has, therefore, been *one hundred and twelve years* since a similar eclipse happened; and I find that the next similar eclipse will occur on July 11, 1991, or *seventy-six years from the present time.* It is, therefore, only on very rare occasions that such eclipses take place and this fact seems worthy of mention in the historical record of important eclipses.

It may, however, interest the reader to know how or why I happened to make this important discovery, as it has been many years since I was engaged in the discussion of eclipses for chronological purposes. I will, therefore, give a brief account of my investigations which so happily led to this discovery.

In the early summer of the year 1906 I was much embarrassed by a superfluity of leisure, and unable to pass my time agreeably with nothing to do. I had then recently been reading G. H. Darwin's interesting book on "The Tides and Kindred Phenomena," and learned that the mathematical theory of the tides was in a very unsatisfactory condition. I had read in my younger days the explanations of the tides by Newton and by Laplace. These explanations seemed so *plausible* that I then accepted them as correct. But as I had devoted the greater part of my life to the discussion of gravitational problems, the thought occurred to me that possibly a new discussion of an old problem might throw additional light upon a subject which was confessedly very obscure. I therefore concluded to undertake a critical discussion of the theory of the tides, and the discovery of the remarkable eclipse came as a bi-product of that discussion. My leisure has

since been pleasantly devoted to a study of the tides and other kindred problems.

In my investigation of the tidal problems I have based my work on the two following postulates; namely:

FIRST: *If a solid body of any figure whatever be covered by a fluid in equilibrium, the gravity at every point of the surface will be the same;* and

SECOND: *If the fluid covering a solid body be free to flow, and the gravity at different points of its surface be disturbed in any manner whatever, the fluid will flow from points where gravity is less to points where gravity is greater; and it will continue to flow until the gravity at all points of the surface becomes equal.*

If these postulates in regard to the equilibrium of fluids be correct the problem of the tides becomes greatly simplified, and instead of being the most *difficult,* it becomes the *simplest* problem of celestial mechanics. For it is a very simple problem to calculate just how much the earth's gravity at any point of its surface is affected by the attraction of the sun and moon. Now when the sun or moon is overhead we know the gravity at the earth's surface directly underneath them is lessened, and we also know that the gravity at all points where the sun or moon is in the horizon is increased by their attraction. It therefore follows from the second postulate that the water directly under the sun or moon will flow away towards the horizon in every direction; and instead of being heaped up under the moon as claimed by Newton and his successors, will be dispersed along a great circle of the earth whose pole is directly under the sun or moon, thus making a thin ribbon or narrow zone of high water of uniform depth and extending completely around the earth, instead of being piled up in the form of protuberance under the moon.

It also follows that there will be a zone of low water directly under the moon instead of a protuberance of high water as claimed by Newton.

Now since there are two disturbing bodies, the sun and the moon, acting independently of each other, it is evident that there will be two independent high-water waves passing completely around a great circle of the earth; and since all great circles intersect or cross each other at opposite extremities of a diameter, it follows that there will always be two points of intersection, or two places of high water, which may be observed at all times, provided we know where to look for them. It also follows that high tides are not restricted to the times of new and full moon, but exist at all times.

The problem of the tides is therefore greatly simplified and reduced to one of finding where the high-water waves produced by the attraction of the sun and moon cross each other, for at these points the single wave is equal to the sum of the two separate waves; and the computation of the places where the tidal waves cross each other is very easy and much simpler than the computation of an eclipse.

The plane of the solar tidal wave is always perpendicular to the ecliptic, and passes through the center of the earth and poles of the ecliptic; and its position is known at all times. The plane of the lunar tidal wave is always perpendicular to the plane of the moon's orbit; but as the moon's orbit is inclined to the ecliptic by about 5°, it follows that the poles of the moon's orbit are always at a distance of 5° from the poles of the ecliptic. But the inclination of the moon's orbit to the ecliptic is always the same, while the nodes of the orbit on the ecliptic are in motion, and perform a complete revolution in about nineteen years. It follows from this that the poles of the moon's orbit move in a small circle of 5° radius around the poles of the ecliptic, making a revolution in nineteen years. The position of the lunar tidal wave thus becomes known at all times; and since the position of the solar tidal wave is also known at the same time, it becomes an easy matter to calculate the place of their intersection, which is the place of high tide.

Now since the moon's nodes are moving backward on the ecliptic 1°.5649 during each lunation, it follows that the tides of no two consecutive lunations will be precisely the same; but they may be more easily calculated than most other celestial phenomena.

In the early spring of the present year (1915) I had so far completed the construction of mathematical formulas for the computation of the tides, that I actually computed the latitude at which the two tidal waves crossed each other at noon of each day during the lunation between May 13 and June 13. This calculation led to the discovery that, whatever may be the relative declinations of the sun and moon at the moment of conjunction or opposition in right ascension, the two tidal waves will always cross each other exactly at the equator; and at the distance of 90° both east and west from the meridian on which the sun and moon are situated. During this lunation the two tidal waves crossed each other at an angle which varied between 4° 20′ and 90°; and the latitudes at which they crossed each other were less than 40° during about *three* days, at the times of new and full moon; while during the twenty-six or twenty-seven remaining days of the lunation the high water was confined within the latitude of 45° and 70°, making a *typical* high-water zone of about 25° in breadth.

Now it will be remembered by readers who are familiar with tidal history, that both Newton and Laplace were greatly embarrassed by the fact that the highest tides did not occur at the time when the acting forces were the greatest, but about a day and a half later; and in order to explain this default of theory, they were obliged to *assume* the operation of *fictitious* or *imaginary causes*. The observations on which their theories were based were made in southern England or northern France, in latitudes in which the united tidal wave did not *usually* reach until about a day and a half *after* the time of new or full moon; and the reason it was not observed was not on account of its non-existence but because it was on duty in another place.

We shall now consider the united tidal wave during the lunation beginning with the full moon of July and ending with that of August. According to the data given in the *American Ephemeris,* the two tidal waves at the instant of conjunction on August 10 made an angle with each other amounting to only 43.8″; so

that they were practically superposed the one upon the other throughout their whole extent and reaching entirely around the earth. But as the lunar tidal wave travels over the earth's surface about thirteen times as fast as the solar tidal wave, they soon part company near the equator, each wave revolving around its own polar axis; and at the end of a single day the latitude of the united tidal wave will be found at 61° 40′ and the two tidal waves will cross each other at an angle of about 11° 20′. The united tidal wave will then remain on or very near to the parallel of 62° of latitude until near the end of the lunation; and there would be a daily succession of uniformly high tides on that parallel of latitude during nearly a whole month.

We have thus far considered only that portion of the tidal waves which rises *above* the normal surface of the ocean; but the water can not rise at any given place on the earth's surface without an equivalent depression at some other point; and a correct theory of the tides will explain equally well all the conditions incident to their formation. Now we know that the earth's surface-gravity is *diminished* by the attraction of the sun and moon at all points of the surface that are less than 54° 44′ of angular distance from those bodies, and *increased* for all greater distances. It therefore follows that all fluids that are under the sun and moon and are free to flow, will flow *away* from the point directly under the sun or moon, instead of *towards* it, as required by the present accepted theory of the tides. This follows for two reasons: *First,* because the earth's gravity is greater in that direction, and, *second,* because the *tangential* forces of the sun and moon actually *push* all bodies in that direction. This is one of the most beautiful and interesting consequences arising from the gravitation of matter; for, were the manner of its action to be reversed, the earth would no longer be habitable by man or beast; for the sun would be hidden by a perpetual cloud by day, and the moon by night; and neither of the luminaries would be visible except at rare and uncertain intervals.

Sir John Herschel in his "Outlines of

Astronomy" has called attention to the *unexplained fact* that the *full moon* tends to disperse the clouds under it. This follows as a necessary consequence of gravitation; but it is not restricted to the *full moon*, but is in active operation at all times by both sun and moon. The fact is however most easily observed at the time when the sun is absent.

Incidentally we may mention that were the moon's orbit in the plane of the ecliptic, the eclipse conditions of the tenth of August would be mostly repeated at each new moon; but the tidal phenomena would be fundamentally different. In the supposed case the crossing of the two tidal waves would be constantly at the pole of the ecliptic during the whole lunation, and the high tides would be confined to the latitudes of the arctic and antarctic circles. If, at the same time, the earth's equator were shifted into the ecliptic, there would be a *constant elevation* of water at both poles of the earth, while all other places on the surface of the earth would have four simple tidal waves each day. The general problem of the height of the tidal wave at any time and place on the earth's surface can not be considered here, but tables for that purpose have already been computed, though still unpublished.

We see from this exposition of the subject that all the infinite variety of tidal phenomena are fully explained by the operation of the forces of gravitation as developed under existing conditions in the solar system. The eclipse of August 10 represents a case in which the forces of the sun and moon act in perfect harmony during a few minutes of time; but it recurs at such infrequent and uncertain intervals that nothing useful can be learned from a single performance unless there be some known theoretical connection with preceding and subsequent events. The problem of the tides, which has been aptly called the *"Riddle of the Ages,"* and designated in despair by an ancient philosopher as *"the tomb of human curiosity,"* may therefore now be considered as completely solved.

JOHN N. STOCKWELL

CLEVELAND,
November 4, 1915

ON THE DEGREE OF EXACTNESS OF THE GAMMA FUNCTION NECESSARY IN CURVE FITTING[1]

THE note by Mr. P. F. Everitt in a recent number of this journal[2] discussing an earlier note by the present writer[3] seems so likely to obscure the essential point and purpose for which the earlier note was written that it appears desirable to advert to the subject once more.

In practical biometric work the gamma function is *chiefly* (though of course not entirely) used in connection with the fitting of Pearson's skew frequency curves, where such function appears in the expression for y_0. In other words, the exactness of approximation to the gamma function in these cases can affect nothing but the calculation of the ordinates and areas of the fitted curve. The writer finds it difficult to conceive of such circumstances in the ordinary prosecution of practical statistical researches as would necessitate or warrant the calculation of the ordinates or areas of a frequency curve to more than two places of decimals. This being the case, it seemed desirable, in the earlier paper, to call attention to the fact that a quite sufficiently "exact" approximation to the values of the gamma functions could be made by simple interpolation in a table of log $\lfloor n$.

In order that the statistical worker may form his own judgment as to what degree of exactness in approximating the gamma function is necessary in calculating y_0, Table I. is presented. This table shows, for four different skew frequency curves, the change produced in y_0 by altering the logarithm of the term involving gamma functions by the following amounts: .0000001, .000001, .00001, .0001 and .001. The curves used for illustration are taken from Pearson's memoir "On the Mathematical Theory of Errors of Judgment, with Special Reference to the Personal Equation."[4]

The curve marked I. in the table is Pear-

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 90.
[2] SCIENCE, N. S., Vol. XLII., pp. 453–455, 1915.
[3] SCIENCE, N. S., Vol. XLI., pp. 506–507, 1915.
[4] *Phil. Trans.*, Vol. 198*A*, pp. 235–299, 1902.

son's "Bright-line" (3) curve[5] and has the equation

$$y = 53.359\left(1 + \frac{x}{11.0856}\right)^{3.96821}\left(1 - \frac{x}{14.4504}\right)^{5.17262}.$$

Curve II. is Pearson's "Bisection" (3) curve[6] and has the equation

$$y = 71.56246\left(1 + \frac{x}{11.349400}\right)^{5.41665}\left(1 - \frac{x}{6.998136}\right)^{3.33995}.$$

Curve III. is Pearson's "Bisection" (2–3) curve[7] and has the equation

$$y = 59.43126\left(1 + \frac{x}{16.16672}\right)^{9.763885}\left(1 - \frac{x}{13.55284}\right)^{8.185180}.$$

Curve IV. is Pearson's "Bisection" (1–2) curve[8] and has the equation

$$y = 56.2136\left(1 + \frac{x}{28.15012}\right)^{35.390655}\left(1 - \frac{x}{37.69023}\right)^{47.384605}.$$

It will be noted that these are all Type I curves and represent a rather wide range of values of the a's and m's. The expression for y_0 in a Type I curve is

$$y_0 = \frac{N}{b} \cdot \frac{m_1{}^{m_1}m_2{}^{m_2}}{(m_1 + m_2)^{m_1 + m_2}} \cdot K,$$

where

$$K = \frac{\Gamma(m_1 + m_2 + 2)}{\Gamma(m_1 + 1)\,\Gamma(m_2 + 1)}.$$

The table shows the change in the maximum ordinate, y_0, produced by altering $\log K$ to the amount indicated.

TABLE I

Showing the Maximum Effect on an Ordinate of the Curve Produced by a Change in the Value of the Log Gamma Term of the Indicated Amount

Curve	Amount of Change in Log K				
	.0000001	.000001	.00001	.0001	.001
I......	.00002	.00013	.00123	.01229	.12303
II.....	.00002	.00016	.00164	.01647	.16496
III...	.00001	.00014	.00137	.01369	.13700
IV....	.00001	.00013	.00130	.01295	.12958

[5] *Loc. cit.*, p. 287.

[6] *Loc. cit.*, p. 288.

[7] *Loc. cit.*, p. 288.

[8] *Loc. cit.*, p. 289.

From this table it is evident that:

1. An alteration of as much as one in the third decimal place in $\log K$ makes a change in the maximum ordinate of between 1 and 2 in the first decimal place, an amount practically negligible in many curve-fitting studies.

2. A degree of approximation to $\log \Gamma(n)$ such as is obtained by interpolation from a table of $\log \underline{|n}$, when *only second differences* are used in the interpolation,[9] involves errors in the fourth decimal place in $\log \Gamma(n)$, or the fifth for values of $n > 25$ *circa*. These mean errors of the order of .02 *ca.* in the maximum ordinate (and, of course, smaller absolute errors in all other ordinates).

3. Interpolation from a table of $\log \underline{|n}$ using second differences is, as we concluded in the earlier paper, quite sufficiently exact for all practical curve-fitting purposes. If any one desires to use ten-place logarithms or some other method, and make all his computations precisely exact to seven (or for the matter of that to 15, 20 or 50) places of figures he may, of course, do so. It is reasonably open to question, however, whether the *additional* contributions to knowledge which may fairly be expected to accrue from such procedure are likely to be of such magnitude or originality as to justify the labor.

Raymond Pearl

THE ORIGIN OF LOST RIVER AND ITS GIANT POTHOLES

In a short article in Science in 1913,[1] Mr. Robert W. Sayles, of Harvard University, described and sought to explain the block-filled gorge and giant potholes of Lost River, in the Kinsman Notch, New Hampshire. During a first visit to the place, last summer, I saw certain features which seem worthy of attention, in formulating any working hypothesis of the origin of the phenomena.

As Mr. Sayles stated, Lost River is a small stream which flows eastward from the notch between Mt. Moosilauke and Mt. Kinsman, eddying and cascading beneath a deep pile of huge angular blocks and rifted ledges for a

[9] *Cf.* Table I. of the writer's earlier paper.

[1] Vol. XXXVII., pp. 611–613.

distance of over a quarter of a mile. The ledges and fragments are all of one type of rock—a coarse granite gneiss—which also outcrops in cliffs on the spur of Mt. Kinsman immediately above the gorge of Lost River, and appears in a talus-like mass of blocks on the steep slope between these cliffs and the gorge. In many cases the blocks appear to have been shifted very little from the ledges against which they lie in tipped or overturned positions; in other cases they are poised in such a way as to make it seem likely that they have been moved a considerable distance. The potholes in question include several semi-cylindrical pits or alcoves of from 15 to 25 feet diameter, and numerous holes and curved channels of much smaller size, similar to the potholes at Agassiz Basin, four miles down the stream. The giant potholes are in no case complete or even approximately so, but appear to have been cracked up and dislocated by the same agency which jostled the blocks generally, along the line of the brook.

In his paper Mr. Sayles considered three agents as possible factors in the breaking up of the ledges and scattering of the blocks: (*a*) frost action, (*b*) disruption by a moving glacier, and (*c*) earthquake movements along the line of the gorge, attended by rock falls from the cliff above it. He considered frost action inadequate because of the depth to which the ledges have been ruptured and displaced, and because in the lowest caverns there are "cases where blocks which have slipped from between other huge blocks in place have left the upper and lower blocks entirely unmoved in the solid ledge"; he rejects disruption by the moving ice sheet for the same reason, adding to it the circumstance that no erratic material occurs among the blocks, and that in one case a block has been shifted four inches against the direction of advance of the ice sheet. He adopts the theory of earthquake movement and rock fall because of the close association of the blocks of the gorge with the inclined heap of blocks on the overhanging slope, on the one hand, and with the cracked and torn ledges beside the stream on the

other; because of lateral movements among the blocks, of the pell-mell manner in which they are heaped, and because of "smooth slickenside-like patches." It is conceived that after the potholes had been excavated, by a large glacier-fed torrent heading in the Kinsman Notch, an earthquake, originating along the line of the gorge, cracked the river-worn ledges and jostled the fragments, shaking down masses, at the same time, from the cliffs on the hill near by.

After looking over the phenomena at Lost River, it does not seem to me that the facts warrant a preference for the earthquake theory over that of glacial sapping and frost action; nor do I feel convinced that the "giant potholes" are products of torrent action. My reasons are these: (*a*) Positive evidence of earthquake movement seems to be meager if not wholly absent. I did not see the "slickenside-like patches" mentioned by Mr. Sayles, nor any other marks of faulting, although I looked for them. The presence of one or two such surfaces, however, even if *bona fide* slickensides, would not necessarily prove postglacial faulting; for small faults, probably of earlier date, are common throughout the White Mountain region. If, as Mr. Sayles supposes, the earthquake rift follows the gorge, it would be natural to expect slickensides to be extensively and distinctly developed. (*b*) The presence of the inclined heap of blocks at the foot of the cliffs, near the head of Lost River, does not seem to me to demand an earthquake. It is well known that rock falls may result from other causes. One may suppose, for instance, that during the evacuation of the notch by the ice sheet, insecure masses of rock on the crags above Lost River, and angular fragments of the same, occupying an englacial position in the ice near by, would slide or fall to the ground as soon as their support vanished, and would produce a heap of blocks such as we see here. In the transportation of these rock falls to points beyond the foot of the cliffs, an inclined floor of stagnant, melting ice might play an important part. It is also conceivable that the production and accumulation of talus, by ordinary processes, might proceed at an ab-

normally rapid rate during the seasons immediately following the retreat of the ice sheet, and that a mass of angular blocks might be left which, because of its uniformly weathered aspect, would appear to have gained little or nothing from annual frost action within more recent time. In either case, an earthquake would be unnecessary to the theory. (c) I agree with Mr. Sayles that the extent of fracturing and dislocation in the gorge itself is too great to be attributed to frost action under ordinary circumstances, both as to the depth reached and the amount of movement registered by the blocks; yet I can not see why plucking or quarrying of blocks by the ice sheet, supplemented by abnormally severe freezing and thawing, as the last vestiges of the ice sheet melted away from the pass, is not a perfectly valid alternative hypothesis. In plucking a large joint block from its place in the ledge, the ice sheet might rotate it so that one end of the block would be moved a few inches in a direction opposite to glacial movement, while the other end was moved forward. Even a case where a block had been moved bodily in a direction opposite to glacial movement, but through a space of only a few inches, as reported by Mr. Sayles, could be accounted for by the action of ice in crevices and angular "cavities" between the blocks at the close of the period of actual glaciation, when the ice surrounding the blocks had lost its ability to move *en masse,* but expanded and contracted in response to temperature changes, somewhat as capillary water and frost behave, in crystalline rocks, but on a much large scale. "Lateral movement" among the blocks, and "pell-mell arrangement" would be natural results of this type of ice action.[2] For these reasons it seems to me that the facts thus far reported do not demand the occurrence of an earthquake at Lost River, but are adequately met by the hypothesis of glacial plucking, followed by rock falls and frost work on a scale larger than has been possible since the last remnants of glacial ice vanished from the Kinsman Notch.

[2] See paper by J. B. Tyrrell, on ''Rock Glaciers or Chrystocrenes,'' *Journal of Geology,* Vol. XVIII., 1910, pp. 549–553.

The size of some of the "giant potholes" is extraordinary. Although they may have been produced by a glacial torrent passing through the notch and on through Agassiz basin, where tortuous channels and large torrent-worn cauldrons are well developed, there are two features which lead me to question the reality of such an origin. (a) In more than one place, where a concave niche or alcove in the wall of the gorge suggests the side of a pothole, from which the other sides have been removed, I saw a curved joint crack in the ledge, one or two feet back of the concavity, and approximately concentric with it. The detachment of the intervening concavo-convex slab, by frost or glaciation, would have left an alcove equally cylindrical in form to, but of larger radius than the "pothole." (b) I was shown by Mr. E. R. Grinnell, superintendent of the reservation, examples of blocks with convex sides, which seem to match the concave niches or incomplete "potholes." One of these abuts against one of the giant potholes, near "the guillotine," and from its shape and form a pegmatite vein which traverses it appears to have dropped from the side of the ledge so as to produce what at first sight would be accepted as part of a huge pothole. Nowhere else have I seen examples of joint cracks with such sharp curvature, yielding partial cylinders of 15 to 25 feet diameter; but their existence here is certain. The question whether the giant potholes are surviving portions of real, torrent-carved potholes, or are imitative forms left by the extraction of joint blocks with curved sides can only be settled by careful measurements of the concave and convex surfaces and a geometrical study of the relations between the ledges and the blocks which still rest against them. As yet no large water-worn boulders seem to have been found in the largest "potholes."

As regards both the true character of the giant potholes, and the earthquake theory, it appears, therefore, that the geological history of Lost River deserves further study.

J. W. Goldthwait

Dartmouth College,
October 2, 1915

SCIENTIFIC BOOKS

Feeble-mindedness: Its Causes and Consequences. By H. H. GODDARD. New York, Macmillan Company, 1914. Pp. xii + 599.

Like all of Goddard's writings, this is full of interest for the large number of those who, in these days of prolonged peace at home, have the privilege of considering social problems. If we, too, were at war, with us, also, "social problems" would sink into utter insignificance beside that of national existence.

Goddard's book may be divided into four parts, (1) the definition and scope of feeble-mindedness, (2) family histories of the feeble-minded, (3) "causes of feeble-mindedness"—with special reference to heredity and (4) some practical applications—eugenical and other.

1. The definition of feeble-mindedness accepted by Goddard is "a state of mental defect existing from birth or from an early age and due to incomplete or abnormal development in consequence of which the person affected is incapable of performing his duties as a member of society in the position of life to which he was born." This is a good definition. It follows, at once, as a corollary that feeble-mindedness is not a biological, but a *social* term; that many a person whom we regard as mentally unfit might not be feeble-minded in his native country of Central Africa or even the Adirondack Mountains, for he might be capable of performing the simple duties of the chase and fighting or rough agriculture demanded "in the position of life to which he was born." If we consider separately the higher grades of the feeble-minded, the morons, the non-biological nature of feeble-mindedness is still more obvious; "one . . . *incapable* from mental defect existing from birth . . . (a) of competing on equal terms with his normal fellows or (b) of managing himself and his affairs with ordinary prudence." Accepting this British definition, Goddard discusses the kinds of people to be included in the moron group of feeble-minded and the anti-social acts they perform. Thus, he considers criminality, alcoholism, prostitution, pauperism and truancy and finds that of criminals at least 50 per cent. are "defective"; at the root of much

intemperance "feeble-mindedness" lies; "50 per cent. of prostitutes are feeble-minded"; "50 per cent. of the inmates of our almshouses are feeble-minded," and of truants 80 per cent. are feeble-minded. These are truly striking figures. But as the reviewer has considered this discussion he has felt as if groping in a fog. If feeble-mindedness is a social and relative term how can we seek to find a definite percentage of it in any class by some absolute standard, like the Binet test? Also what is the "mind"; shall we define it as including "intelligence" only, which seems to be the thing measured by the Binet scale, or shall it include "emotional control" which is clearly not measured by the Binet scale? Yet, is it not lack of emotional control that is at the bottom of much so-called crime, alcoholism, sex offense and truancy? And is it not also true that the question of the degree of correlation between "intelligence" and "emotional control" remains largely an academic one?

It seems to the reviewer more significant to inquire more deeply into the causes of any anti-social act than to classify the offender as feeble-minded or not feeble-minded by the Binet or other scale. It seems to the reviewer that anti-social behavior (*i. e.,* offense against the mores) may have the following bases:

(1) Ignorance of the mores, merely through lack of opportunity to learn the mores (the merely improperly taught offender).

(2) Ignorance of the mores through lack of capacity to understand what society expects (the feeble-minded offender, *sensu strictu*).

(3) Knowledge of the mores, accompanied with a social blindness—an inability to have the action controlled by a knowledge of what society expects of one—because of a lack of the gregarious, social or altruistic instinct. Here belong the extreme individualists, including the anarchists, and the others who say: Why should I govern my actions to meet the expectations of society; what right has society over me, anyway?

(4) Knowledge of the mores, with presence of the social instincts, but with inability to meet the expectations of society through insufficient inhibition or self-control. This insufficiency

may be a general constitutional and permanent one, or it may be temporary (often more or less periodic) due to abnormal internal secretions or other causes. Here belong, among others, the hyperkinetic, the hysterical and epileptoid offenders.

It would seem as though future progress in an understanding of conduct would lie less in a classification of people into the feeble-minded and normal than in a study of the individual's early training, mentality, social instincts and inhibitions.

2. The great body of the work (pp. 47 to 434) consists of the descriptions of 327 cases of feeble-minded individuals, with the family history as far as could be obtained. These are grouped under the heads: hereditary, probably hereditary, neuropathic ancestry, accident, no assignable cause, and unclassified. These pages contain many interesting and significant details.

3. In the third section dealing with "causes," the author properly criticizes much of the *post hoc ergo propter hoc* argumentation which is extremely widespread among medical writers. Goddard's conclusion that about 80 per cent. of the cases of feeble-mindedness with which he deals are hereditary, probably hereditary or neuropathic is interesting; yet from the nature of the case so precise a figure based on materials that in their nature are unprecise must be regarded as a rough judgment and one of which too much may readily be made. In this section is discussed the heredity of "feeble-mindedness" and the conclusion is reached that normal mentality is dominant over feeble-mindedness. Goddard confesses to having been prejudiced against the view "that the intelligence even acts like a unit character. But there seems to be no way to escape the conclusion." Now, since feeble-mindedness is a social and not a biological term, it would seem almost absurd to seek to find a law of its inheritance. The case seems to be this, a large proportion of the feeble-minded are such because of general failure of development of the intellectual centers. A "general intelligence" there well may be, as he concludes; but that does not pre-

vent the hypothesis of special talents (or their lack) and special elements of self-control. Thus, there may well be an hereditary basis for many of the mental differences between persons, whether "normal" or "feeble-minded."

4. The practical applications from Goddard's study he finds in applied eugenical procedures, especially the prevention of propagation of the defective stock. While our efforts to segregate must be increased, sterilization is useful in cases that can not be otherwise reached, and many mental defectives may well be cared for at their homes.

In general, the book shows some haste in composition and the latter is in spots defective, but nevertheless, it will be everywhere regarded as a useful piece of work and one that every one who is concerned with the troubles of human society will prize.

C. B. DAVENPORT

COLD SPRING HARBOR, N. Y.,
    October 31, 1915

Handwörterbuch der Naturwissenschaften. Herausgegeben von PROF. DR. E. KORSCHELT, Marburg (Zoologie), PROF. DR. G. LINCK, Jena (Mineralogie und Geologie), PROF. DR. F. OLTMANNS, Freiburg (Botanik), PROF. DR. K. SCHAUM, Giessen (Chemie), PROF. DR. H. TH. SIMON, Göttingen (Physik), PROF. DR. M. VERWORN, Bonn (Physiologie), DR. E. TEICHMANN, Frankfurt a. M. (Hauptredaktion). Jena, 10 volumes, in 4°, 1912–15. Verlag von Gustav Fischer.

The splendid work issued under the above title and with the editorship indicated is worthy of close inspection from those interested in the various lines of natural science included. The initial lieferungen have already been reviewed by Professor Arthur Gordon Webster[1] in these pages and I do not doubt that now on the completion of the work he will favor us with a discussion from the side of the physical sciences. The desirability of having the attention of workers in the natural sciences directed to the "Handwörterbuch" has led to the writing of this review.

[1] SCIENCE, N. S., Vol. XXXVIII., No. 972, pp. 230–233, August 15, 1913.

Professor Webster has already discussed the position of the work among the encyclopedias of the world and has mentioned the excellence of the short biographical sketches, as well as touching on various phases of the biological articles. As suggested by Professor Webster in regard to mathematics, anatomists will be keenly disappointed to find *their* science also neglected, save in the introduction of anatomical work into other branches of natural science; but the "Handwörterbuch" will be found extremely useful in certain lines, none the less. One interesting feature, mentioned by Professor Webster, is the up-to-dateness of the various articles, illustrations from the younger or more recent writers being chosen in preference to time-honored cuts. Perhaps this is partially due to the authors of the individual articles, but it is also evidently the policy of the editors to have the work as complete as possible. The articles are, in general, brief, some of them well illustrated, with the chief sources of literature given at the end.

It has been the privilege of the writer to use this work extensively in a compilation of a biographical nature, and it is a pleasure to say that he has found the "Handwörterbuch" extremely useful. The biographical sketches, of which there are a great many, are short, without illustrations, and give at the close the important sources of information concerning the individual discussed. This feature is very important in a historical study of biology and is a great improvement over the Encyclopedia Britannica, for instance, where sources of reference are mentioned only incidentally. Many names are not included which might justly belong in the work. Mendel is inserted as an afterthought at the close of volume ten. None of the more important human anatomists are included, even those who were engaged in zoological work.

The special articles have been assigned by the editors to prominent scholars in the various lines of work. The recent Amphibia, for instance, are treated in a very complete way by Dr. J. Versluys, in an article covering twenty-five pages. The illustrations might have been better chosen, but they represent the general features of amphibian morphology. The "Paleontology of the Amphibia" is treated by J. F. Pompeckj, a writer well known to students of paleontology. The article, covering nine pages, is well illustrated, the figures being chosen from among the papers of Williston, Dollo, von Meyer, Moodie and Zittel. The same subject is covered much more fully in volume nine, under the heading "Stegocephalen." Friedrich von Huene is the author of this article, which covers seven pages, richly illustrated, with a good list of recent literature at the end. It is rather unfortunate to separate the discussion of Amphibia and Stegocephalia, since the present writer is firmly convinced that they are both members of the same groups; that is, all of them are Amphibia. Other remarks and illustrations regarding the extinct Amphibia are to be found under the various geological periods. Under "Karbonformation" the only figured representative of the rich vertebrate land fauna of the Coal Measures is the much-worn and time-honored figure of *Lepterpeton Dobbsii,* described by Huxley from the Coal Measures of Ireland, but the discussion, by W. Kegel, is well balanced.

Paleontologists will find the work extremely useful, and especially teachers of paleontology will have a work to which their students can refer for a discussion of general topics, which, in general, have been brought well down to date. Some of the articles are especially refreshing in the presentation of new ideas. Gustav Tornier's article on the paleontology of the reptiles, covering forty pages, is an instance of this. The article is very well illustrated; the figures being chosen from papers by Broili, Broom, Newton, Osborn, Fraas, Tornier and Eaton. Tornier's original reconstructions of *Diplodocus* and *Stegosaurus,* have already attracted the attention of paleontologists and have been discussed especially by Matthew. It is rather startling to see our old friend *Triceratops* sprawling on the ground like a horned toad, but such new ideas are worth while in keeping our interests alert. It is most unfortunate that, in a work of this nature, the important researches of Case and

Williston on the Permian reptiles of America should have been entirely ignored. Some of the many, and much worn, illustrations of the Dinosauria might easily have been replaced by excellent illustrations from one or the other of these writers.

The paleontology of fishes is very fully covered by Pompeckj, illustrations and discussions of typical forms of the various groups being chosen. The reconstruction of the Devonian *Paleospondylus* by Sollas, based on serial sections, is given. The restorations and drawings by Patten and Traquair of the early Devonian Placodermi are well shown in many illustrations, as well as such recent figures as Hay's *Edestus crenulatus,* which is one of several early elasmobranchs figured. Many well-known restorations and figures of fish anatomy from the writings of Dean, Dollo and Woodward complete the work.

The general discussion of the recent mammals by W. Kukenthal is followed by a sixty-four page article by O. Abel on the paleontology of the mammals. This latter section is illustrated by 122 figures, which are well chosen, as we would expect from such an eminent student as Abel.

The article on " Zelle und Zellteilung " covering one hundred and seventy pages, richly illustrated with 225 figures, is one of the more extensive biological articles. It is divided into three sections: (1) Zelle und Zellteilung, Botanisch; (2) Zoologisch; and (3) Zellphysiologie. The botanical section is written by E. Kuster, the zoological section by L. Bruel and the physiology by M. Verworn, each section being followed by numerous references to the important literature.

The anatomy and physiology of the sensory organs, covering sixty-five pages, with eighty-one figures and many bibliographic references, deals with special sense organs throughout the whole range of animal life. The discussion and illustration of this immense subject is necessarily brief and specialists will be disappointed to see their favorite subjects but slightly touched or neglected; however, for a work of this character the article will prove helpful.

The work, taken as a whole, contains many interesting contributions to paleontology and zoology. The articles discussed above may be taken as typical of the other articles in the work. A general index of three hundred and sixty pages closes the work. The individual articles show that a high ideal was adopted, which has been well sustained throughout. The volumes are well printed, the illustrations are clear, and in every way the work lives up to the good reputation so long enjoyed by the press of Gustav Fischer.

Roy L. Moodie

Department of Anatomy,
University of Illinois, Chicago,
October 30, 1915

PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

The eleventh number of volume 1 of the *Proceedings of the National Academy of Sciences* contains the following articles:

1. *Experiments on the Development of the Limbs in Amphibia:* Ross G. Harrison, Osborn Zoological Laboratory, Yale University.

At the time of appearance of the tail bud the anterior limb of *Amblystoma* is already determined in the mesoderm cells of that region of the body wall which lies close to the pronephros and ventral to the third, fourth and fifth myotomes. The prospective significance of this group of cells, as a whole, thus is defined some time before differentiation becomes visible.

2. *A Mechanism of Protection against Bacterial Infection:* Carroll G. Bull, Rockefeller Institute for Medical Research, New York.

Bacteria circulating in the blood are quickly removed when they are agglutinated or clumped, and the clumps deposited within the organs are taken up by phagocytes and digested. They appear not to be destroyed by solution or lysis through the operation of serum constituents of the blood.

3. *On the Life-History of Giardia:* Charles Atwood Kofoid and Elizabeth B. Christiansen, Zoological Laboratory, University of California.

Giardia muris and *Giardia microti* produce a readily recognizable enteritis in mice, and both binary and multiple fission take place in the free non-encysted stage—there is no *Octomitus* stage. The morphological characters separate six species. The parasite in mice appears to be distinct from that in man.

4. *The Inorganic Constituents of Alcyonaria:* F. W. CLARKE and W. C. WHEELER, United States Geological Survey, Washington.

The stony corals have been repeatedly analyzed, and with generally concordant results. Thirty analyses here made have confirmed the older data. The object of the investigation is to determine what each group of organisms contributes to the formation of marine limestones. The highest proportions of calcium phosphate are commonly associated with high values for magnesia.

5. *An Experimental Analysis of the Origin and Relationship of Blood Corpuscles and the Lining Cells of Vessels:* CHARLES R. STOCKARD, Department of Anatomy, Cornell University Medical School.

Vascular endothelium, erythrocytes and leucocytes, although all arise from mesenchyme, are really polyphyletic in origin; that is, each has a different mesenchymal anlage.

EDWIN BIDWELL WILSON

SPECIAL ARTICLES

INTERFERENCES WITH TWO GRATINGS

IF two identical grating are placed with the ruled faces and rulings in parallel and the horizontal and transverse axes of their spectra (of the same side and order) in coincidence, white light passed through them from the collimator of a spectrometer shows intense, nearly equidistant, vertical interference fringes in the telescope. The path difference is subject to the equation $e(1 - \cos \theta)$, where e is the distance apart of the ruled faces and θ the angle of diffraction. These fringes therefore belong to the coarse set which I described elsewhere. Though not exceptionally sensitive to displacements of either grating, they are available throughout a relatively large interval; *i. e., e* may be increased from coincidence

to over 2 cm. As two stretched films suffice, these strong fringes admit of many practical applications.

A more interesting class of fringes may be observed, when the light used in the same instrument is homogeneous. There are three types of these fringes of constant wave-length. The first of these is obtained with the same adjustment for coincident longitudinal and transverse spectrum axes, but needs a wide slit. Obliquity of the incident rays here replaces the above color difference. The second class appears with a fine slit, coincidence of longitudinal axes, but in the absence of coincidence of transverse axes (in which adjustment the fringes would be of infinite size). They are thus evoked by a difference in the angle of incidence at the two gratings, respectively. Frequently they are seen to best advantage with the naked eye or a lens. They increase in size as the eye is withdrawn from the grating; or if seen in the telescope, if the ocular is either pulled out or pushed in from the position for the principal focus where D lines only are seen. For any given position of the eye they do not vary in size while either grating is displaced from coincident position, to the position of vague evanescence, 4 or 5 millimeters beyond. Both this and the following fringe patterns rotate rapidly with the slight rotation of either grating in its own plane.

The third class is obtained in the absence of a collimator and is due to the varying obliquity of diffuse homogeneous light. The longitudinal spectrum axes must coincide, but the transverse axes need not. They are very strong, best seen with the naked eye or lens, but admit of relatively little displacement of either grating, as they vanish with increasing smallness. They usually lie in a definite focal plane, which recedes to infinity as the gratings are more and more separated.

Finally it is interesting to note that phenomena of a somewhat similar kind may be obtained with reversed spectra.

CARL BARUS

BROWN UNIVERSITY,
PROVIDENCE, R. I.

THE EFFECT OF X-RAY ON THE RESISTANCE TO CANCER IN MICE[1]

It has been shown in previous communications that the resistance to heteroplastic tissue grafts apparently depends on the activity of the lymphocyte. The facts on which this conclusion is based are briefly as follows: The chick embryo, which normally lacks the ability to destroy a heteroplastic tissue graft, if supplied with a bit of adult lymphoid tissue, becomes as resistant as the adult in this respect. Furthermore, an adult animal deprived of the major portion of its lymphoid system by repeated small doses of X-ray, no longer has the power to destroy a graft of foreign tissue, and this tissue will grow actively. The chief characteristic of a failing heteroplastic graft in the unsuitable host is a marked local accumulation of lymphocytes. The histological picture is identical in a failing cancer graft in an immune animal of the same species. Synchronous with the establishment of the cancer immunity and during the period in which the lymphocytes are accumulating around the cancer graft, there is a lymphocytic crisis in the circulating blood. This is found in the actively immunized animals as well as in those possessing a natural immunity, but is totally lacking in animals susceptible to the cancer graft. If the lymphoid crisis be prevented in immune animals by a previous destruction of the lymphoid elements with X-ray the potentially immune animal is changed to a susceptible one.

We have noted that while repeated exposures to X-ray will destroy the lymphoid elements of an animal, one small dose will stimulate these same cells. With this artificial method of producing a lymphocytosis we have attempted to study the relation of this condition to the resistance of mice to their own spontaneous tumors. For evident reasons it was necessary to rule out the complicated question of the direct effect of X-ray on the

cancer. In order to do this we have removed the cancer at operation, and with the cancer out the animal has been subjected to a stimulating dose of X-ray. Immediately after this a graft of the original tumor was replaced in the groin of the animal. As a control the same procedure was carried out, but with X-ray treatment omitted. As a further check to the results cancers were removed from a number of animals and in this set the cancers were exposed directly to the same amount of X-ray that the animals in the first group had received. After this a graft of the tumor was returned to the original host.

The results of these three experiments are to be judged by two criteria. First, whether or not there is a return of the disease, either at the site of removal of the cancer, or at the point of inoculation of the returned graft; and second, the time at which the returned graft starts in active growth, if at all. The figures on these points are given in the following table.

	Immune Per Cent.	Susceptible Per Cent.	Local Recurrence of Tumor Per Cent.	Average Time for Appearance of Graft.
Series I ...	50.0	50.0	21.2	5 wks. and 4 days.
Series II ..	3.4	96.6	48.3	1 wk. and 5 days.
Series III..	0.0	100.0	40.0	1 wk. and 3 days.

Series I. was composed of 52 animals treated by X-ray while the cancer was outside of the body, with later a return of a graft of the tumor. Series II. was made up of 29 control animals in which the cancer was removed and a graft returned without treatment to either animal or tumor. Series III. was made up of ten animals from which the cancer was removed and the cancer subjected directly to the same amount of X-ray that the animals received in the first series, and later a graft of this X-rayed cancer returned to its original host.

It will be seen from these figures that an X-ray dose which produced a lymphocytosis when administered direct to the animal was sufficient to render 50 per cent. of the mice so treated immune to a returned graft of their

own tumor, and in the other 50 per cent. greatly to retard the return of the disease. A similar dose of X-ray given to the cancer direct outside of the body did not influence the subsequent growth of a graft of this tumor when returned to its original host. The contrast between these figures and those of the control series is striking, as is also the number of local recurrences in the two series. If this pronounced result is obtained with one stimulating dose it is probable that a more pronounced effect might be obtained by a second exposure to X-ray after a suitable interval.

JAMES B. MURPHY,
JOHN J. NORTON

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 543d meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, October 23, 1915, called to order by President Bartsch at 8 P.M., with 85 persons present.

Under the heading Brief Notes: Dr. C. W. Stiles recorded observations on blood examinations (cell counts, hemoglobin, etc.) of 600 children, between 6 and 17 years of age, in North Carolina. Dr. Stiles also made remarks on the International List of generic names of birds.

Under heading Exhibition of Specimens: Dr. J. N. Rose showed some interesting examples of humming-birds' nests which he had collected in Brazil the past summer.

The first paper on the regular program was by Professor A. S. Hitchcock, "Collecting Grasses in the Southwest." Professor Hitchcock spoke of his trip during the summer in the region from California to west Texas for the purpose of collecting grasses.

At Grand Canyon was found the rare *Stipa arida* Jones. At Ft. Bragg, Calif., was found *Agrostis breviculmis* Hitchc., known only from this locality and the western coast of South America. It is abundant on the open ground back of the sandy clay cliffs at this point. In a springy place on the side of the cliffs there was a colony of *Phleum alpinum* L., a grass of the high mountains of California. Its occurrence at sea level was very unexpected. At various points in northern California occurs *Danthonia americana* and *D. californica*. In these species the culms disarticulate near the base at maturity. An examination of the swollen base of the detached culms discloses, hidden beneath the sheath and prophyllum, a cleistogamous spikelet consisting of a single floret. The floret and enclosed caryopsis are much larger than those of the panicle.

Cleveland Natural Forest, lying east of San Diego, was visited to investigate *Calamagrostis densa* Vasey. This species known only from the type collection by Orcutt was provisionally united with *C. koelerioides*, by the speaker,[1] but he is now satisfied that the two are distinct species.

An ascent was made of Humphreys Peak of the San Francisco Mountains, near Flagstaff, Arizona. These are the highest mountains in Arizona, the peaks extending above timber line. In the alpine region four species of grasses were found, *Trisetum spicatum, Poa rupicola, Festuca brachyphylla* and *Agropyron scribneri*. Collections were made at several other places of interest: Oracle, about 45 miles north of Tucson, in company with Professor J. J. Thornber; Big Spring, Alpine and Del Rio, in western Texas; and the Guadalupe Mountains of southern New Mexico, especially rich in Mexican species. Professor Hitchcock's paper was discussed by the chair.

The second and last paper of the program was by R. L. Garner, "African Studies; Things in Common Among Men, Apes and Other Mammals." Mr. Garner spoke of the courtship, family life, period of infancy, arrival of puberty, instincts, homes, habits and moral traits of the African anthropoid apes as observed by him in their wild state, during many years of observation in Africa. Among other things he stated that the period of gestation was probably seven months; that the young ape was born with usually 4 teeth present, twin births are exceedingly rare, the female becomes sexually mature at from 7 to 9 years, and the male from 1 to 2 years later, the usual length of life is 20 to 21 years; that their foods are mainly vegetable, but that flesh is an essential part of their diet; that they have no permanent homes, but travel about as nomadic families; that their sleeping position is on their back or side like that of men, they often make their beds 18 to 25 feet off the ground, but the young are delivered in a bed on the ground in a well-drained place; that sight and particularly hearing are acute, but that smell is not much more developed than in man and touch is less acute than in man; that the right of ownership among them is well respected. Mr. Garner concluded by saying he

[1] In Jepson, "Flora of California," 3: 125. 1912.

hoped to return to Africa in the near future and take motion pictures of the great apes.

The society adjourned at 10.10 P.M.

M. W. LYON, JR.,
Recording Secretary

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and seventy-eighth regular meeting of the society was held at Columbia University on Saturday, October 30, 1915. Fifty-one members attended the two sessions. President E. W. Brown occupied the chair. The council announced the election of the following persons to membership in the society: Mr. D. R. Belcher, Columbia University; Professor J. W. Calhoun, University of Texas; Professor Sarah E. Cronin, State University of Iowa; Mr. C. E. Epperson, Kirksville Normal School, Mo.; Dr. Olive C. Hazlett, Radcliffe College; Mr. C. M. Hebbert, University of Illinois; Miss Goldie P. Horton, University of Texas; Professor W. S. Lake, School of Mines and Industries, Bendigo, Australia; Mr. D. H. Leavens, College of Yale in China; Mr. C. T. Levy, University of California; Dr. F. W. Reed, University of Illinois; Professor L. H. Rice, Syracuse University; Mr. J. F. Ritt, Columbia University; Professor D. M. Y. Sommerville, Victoria University College, Wellington, N. Z.; Miss Leila R. Stoughton, Rosemary Hall School, Greenwich, Conn.; Dr. C. E. Wilder, Pennsylvania State College; Mr. A. R. Williams, University of California; Dr. L. T. Wilson, University of Illinois; Dr. F. E. Wright, U. S. Geological Survey. Four applications for membership in the society were received.

A list of nominations for officers and other members of the council to be elected at the annual meeting was prepared for the official ballot for the annual election. A committee was appointed to audit the accounts of the treasurer for the current year.

Twenty members were present at the dinner arranged for the evening, always one of the most pleasant features of the meetings.

The twenty-third summer meeting of the society will be held at Harvard University early in September, 1916. At the seventh colloquium of the society, held in connection with this meeting, courses of lectures will be given as follows: By Professor G. C. Evans, "Topics from the theory and applications of functionals, including integral equations." By Professor Oswald Veblen, "Analysis situs."

The following papers were read at the October meeting:

G. A. Pfeiffer: "Existence of divergent solutions of the functional equations $\phi[g(x)] = a\phi(x)$, $f[f(x)] = g(x)$, where $g(x)$ is a given analytic function, in the irrational case."

C. N. Haskins: "On the extremes of bounded summable functions and the distribution of their functional values."

G. M. Green: "Projective differential geometry of one-parameter families of space curves, and conjugate nets on a curved surface. Second memoir."

G. M. Green: "The linear dependence of functions of several variables."

A. R. Schweitzer: "On the dependence of algebraic equations upon quasi-transitiveness."

H. S. Carslaw: "A trigonometrical sum and the Gibbs phenomenon in Fourier series."

W. F. Osgood: "On a sufficient condition for a non-essential singularity of a function of several complex variables."

Dunham Jackson: "Singular points of functions of several complex variables."

W. F. Osgood: "On functions of several complex variables."

L. P. Eisenhart: "Envelopes of rolling and transformations of Ribaucour."

W. B. Fite: "Note on homogeneous linear differential equations of the second order."

H. S. Vandiver: "Note on the distribution of quadratic residues."

G. D. Birkhoff: "A theorem concerning the singular points of ordinary linear differential equations."

H. S. White: "Closed systems of sevens in a 3-3 correspondence."

W. R. Longley: "Note on a theorem on envelopes."

A. R. Schweitzer: "On the dependence of algebraic equations upon quasi-transitiveness. Second paper."

A. R. Schweitzer: "A new functional characterization of the arithmetic mean."

The San Francisco section of the society held its twenty-seventh regular meeting at Stanford University on November 20. The Southwestern section held its ninth regular meeting at Washington University, St. Louis, on November 27. The annual meeting of the society will be held at Columbia University on Monday and Tuesday, December 27-28. The Chicago section will meet at Columbus, Ohio, in affiliation with the American Association for the Advancement of Science on December 30-31 and January 1.

F. N. COLE,
Secretary